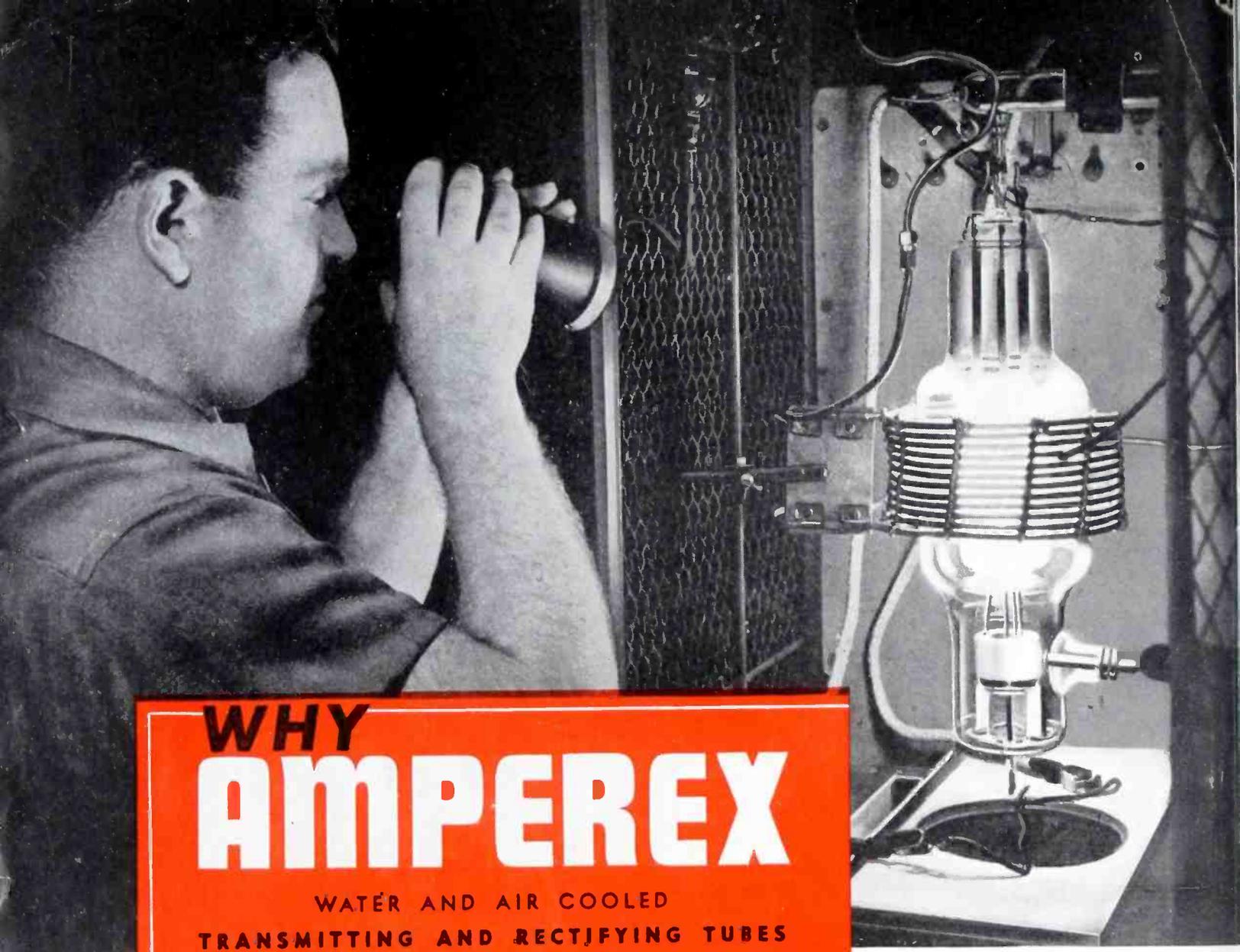


OCTOBER · 1944

electronics



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WHY AMPEREX

WATER AND AIR COOLED
TRANSMITTING AND RECTIFYING TUBES

Pioneering is another "AMPEREXTRA" which has contributed much to the excellence of the more than 100 different types of transmitting and rectifying tubes developed by AMPEREX. For instance, it was AMPEREX engineers who were first to incorporate specially processed graphite anodes in many of our exclusive designs. One superiority of our graphite anodes is reflected in lower average operating temperatures, more uniform temperature distribution, freedom from warping in processing and operation, absence of change in characteristics with time, and a higher initial vacuum which keeps tubes harder and assures longer life. If you are designing new equipment, or plan to improve existing facilities, talk to an AMPEREX engineer.

AMPEREX ELECTRONIC CORPORATION

79 WASHINGTON STREET BROOKLYN 1, N. Y.
Expert Division: 13 E. 40th St., New York 16, N. Y., Cables: "Arlab"

*Studying temperature of anode
(attained during bombardment
schedule) through a pyrometer*



GOOD TO THE LAST DROP ON THE BATTLEFIELD DONATE A PINT OF YOUR BLOOD TO THE RED CROSS

electronics

V. G. B.

OCTOBER • 1944

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McGRAW-HILL PUBLISHING COMPANY, INCORPORATED

JAMES H. McGRAW, Founder and Honorary Chairman

PUBLICATION OFFICE 99-129 North Broadway, Albany, I. N. Y., U. S. A.

EDITORIAL AND EXECUTIVE OFFICES 330 West 42nd St., New York, 18, N. Y., U. S. A.

James H. McGraw, Jr., President; Howard Ehrlich, Executive Vice President for Business Operations; John Abbink, Executive Vice President for Editorial Operations; Curtis W. McGraw, Vice President and Treasurer; Joseph A. Gerardi, Secretary. Cable address: MCGRAW-HILL New York. Member A. B. P. Member A. B. C.

ELECTRONICS, October, 1944, Vol. 17, No. 10. Published monthly, price 50c a copy. June Directory Issue \$1.00. Allow at least 10 days for change of address. All communications about subscriptions should be addressed to the Director of Circulation, 330 W. 42nd St., New York 18, N. Y.

Subscription rates—United States and possessions, Mexico, Central and South American countries, \$5.00 a year, \$8.00 for two years, \$10.00 for three years. Canada (Canadian funds accepted) \$5.50 a year, \$9.00 for two years, \$11.00 for three years. Great Britain and British possessions, 36 shillings for one year, 72 shillings for three years. All other countries \$6.00 for one year, \$12.00 for three years. Entered as Second Class matter August 29, 1936, at Post Office, Albany, New York, under the Act of March 3, 1879. BRANCH OFFICES: 520 North Michigan Avenue, Chicago 11, Ill.; 69 Post Street, San Francisco 4; Aldwych House, Aldwych, London, W.C. 2; Washington, D. C. 4; Philadelphia 2; Cleveland 15; Detroit 2; St. Louis 8; Boston 16; Atlanta 3, Ga.; 821 So. Hope St., Los Angeles 14; 38-9 Oliver Building, Pittsburgh 22.

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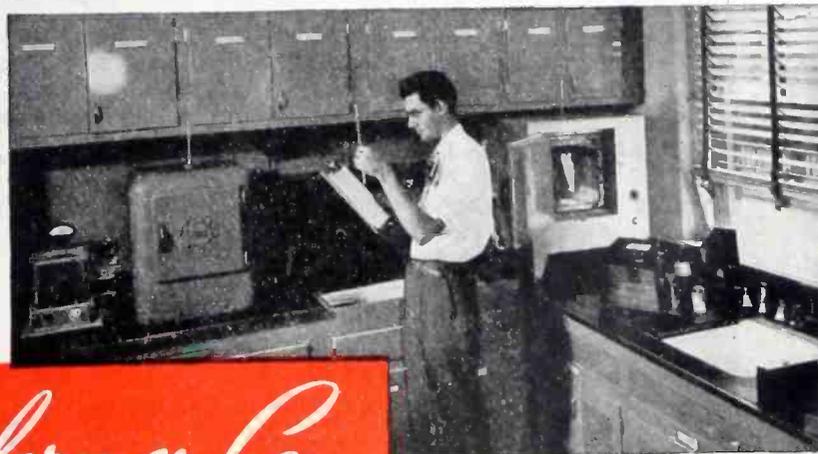
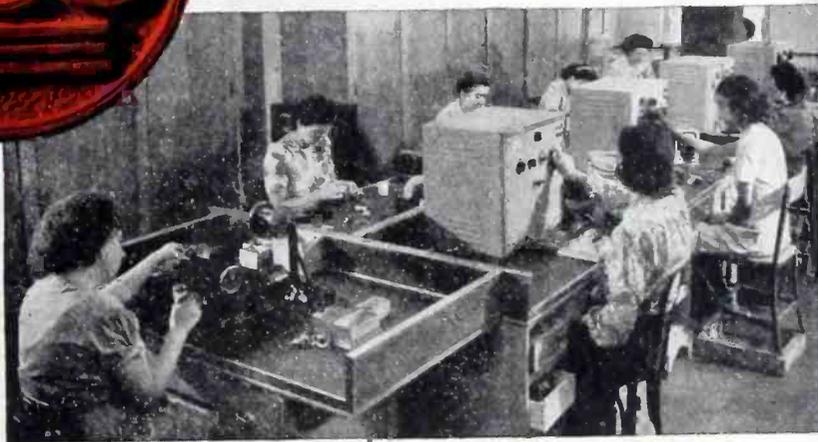
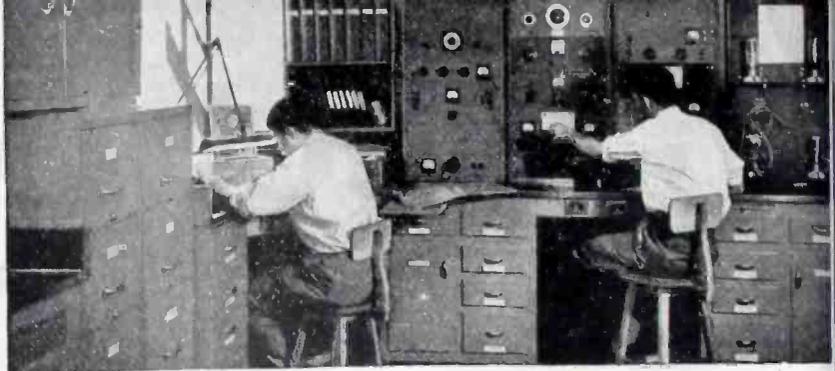
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for your applications . . . war or postwar?*

K & E

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Think of K & E. What product comes first to your mind? Slide Rules, probably. Or think of Slide Rules. What name do you associate with them? K & E of course.

The reason is simple. For years a K & E Slide Rule has been an integral part of every engineer's equipment, from his student days, right on.

The war brought an avalanche of orders for K & E Slide Rules. We have done our utmost to keep pace with it and are rather proud of the job. But we are still prouder of the quality that makes the K & E Slide Rule reputation what it is.

You will find Don Herold's booklet, "How To Choose A Slide Rule" helpful and amusing. Write to Keuffel & Esser Co., Hoboken, N. J.

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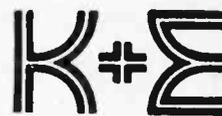
EST. 1867

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MONTREAL



*Drafting, Reproduction, Surveying
Equipment and Materials.
Slide Rules. Measuring Tapes.*

WESTINGHOUSE ELECTRONIC TUBES . . . DOING A JOB ON



THE TUBE THAT

**QUICK LOCAL SERVICE
ON INDUSTRIAL
ELECTRONIC TUBES**

Looking ahead to continued development of electronic equipment in industry, postwar, we now have a plan to make Westinghouse Electronic Tubes quickly and easily available. Stocks of the most widely used tubes are now available through Westinghouse Electronic Tube Distributors and Westinghouse District Warehouses. As rapidly as possible additional types will be added to local stocks to make a complete line of Quality Controlled Westinghouse Electronic Tubes available to everyone.

EVERY FRONT, IN EVERY BATTLE, IN EVERY WAR INDUSTRY

COULDN'T BE MADE
... BUT IT WAS!



The Army came to Westinghouse for a very complex, completely new type of electronic tube. Our engineers didn't say it couldn't be made, but they thought just that. However, when the Army asks for it, you do the impossible. Our engineers sweated it out. They designed, built, tested and shipped the new tube. Then word came back: "It won't work." Instead of making the tube over, we got permission to redesign the apparatus in which the tube was to be used. Result: tube 100% perfect in new apparatus which the Army agreed did a better job than the original—and an order for 2000 tubes *exactly as supplied!*

The engineering resourcefulness and production expansion which made this possible have enabled Westinghouse to multiply tube output 30 times . . . so that today we're not only meeting time and quality "musts" on all Government contracts, but we're also continuing to meet the heavy needs of war industry. Your nearest Westinghouse office or Westinghouse Electronic Tube Distributor will be glad to receive your inquiries. Westinghouse Electric & Manufacturing Company, Bloomfield, N. J.

Westinghouse

PLANTS IN 25 CITIES

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Tobe Capacitors are built to last. From winding to shipping, each step is under rigid inspection to maintain the high standard set by twenty years' experience.

Below is shown a Tobe RLO Type Capacitor. It is impregnated and filled with mineral oil, made with watchful care and—like all Tobe Capacitors—rated conservatively. Let us know about your capacitor problems.

LONG LIFE ASSURED



SPECIFICATIONS—TYPE RLO* CAPACITOR

RATINGS:	600 VDC	Single Units	.01 to 2.0 Mfd.
		Dual Units	.05 to 1.0 Mfd.
		Triple Units	.05 to 0.5 Mfd.
	1,000 VDC	Single Units	.01 to 1.0 Mfd.
		Dual Units	.05 to 0.5 Mfd.
		Triple Units	0.1 and .25 Mfd.

STANDARD CAPACITANCE TOLERANCE—plus or minus 20%**

TEST VOLTAGE—twice D.C. rating

GROUND TEST—2,500 Volts D.C.

OPERATING TEMPERATURE—55° F. to 185° F.

SHUNT RESISTANCE—

.01 to 0.1 Mfd.	—20,000 Megohms
.25 to 0.5 Mfd.	—12,000 Megohms
1.0 Mfd.	—10,000 Megohms
2.0 Mfd.	—5,000 Megohms

POWER FACTOR —1,000 cycles—.002 to .005

MOUNTING HOLE CENTERS: 2 $\frac{1}{8}$ " except for the following capacitance values which are made in containers having 2 $\frac{3}{8}$ " mounting centers:

600 VDC—	Single Units	1.0 and 2.0 Mfd.
	Dual Units	0.5 and 1.0 Mfd.
	Triple Units	.25 and 0.5 Mfd.
1,000 VDC—	Single Units	0.5 and 1.0 Mfd.
	Dual Units	.25 and 0.5 Mfd.
	Triple Units	0.1 and .25 Mfd.

*Data sheets showing complete code number for units having a specific capacitance value and voltage rating available on request.
**Other tolerances available.



a small part in victory today

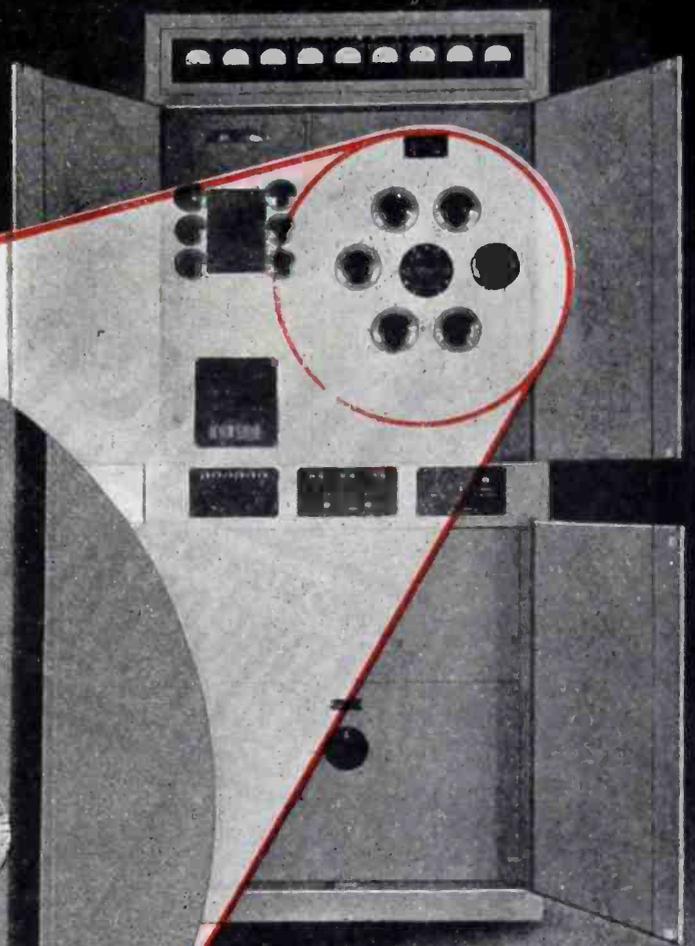
A BIG PART IN INDUSTRY TOMORROW

Photo Courtesy of Southern Pacific Lines

The Final Touch

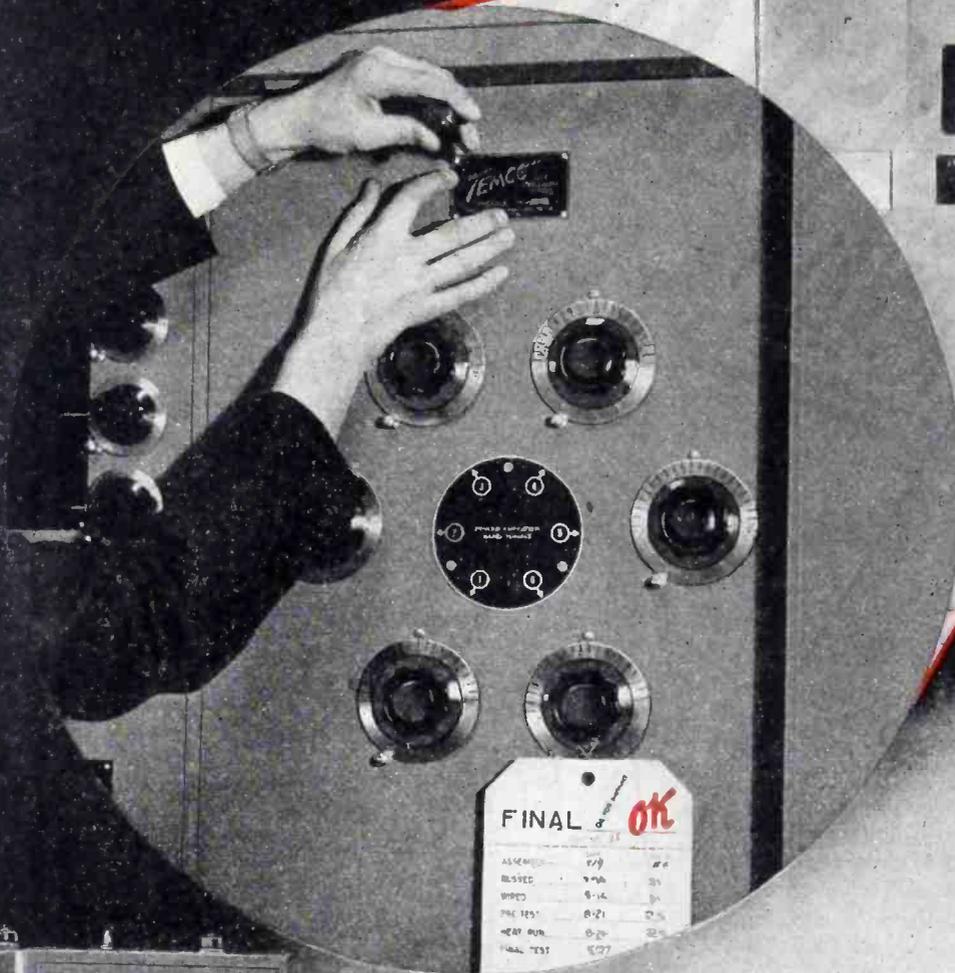
THAT ASSURES

PERFECT CRAFTSMANSHIP



Above: TEMCO Model 1000 AG-CW 1000 watt radio telegraph transmitter with pretuned tank circuits for 6-frequency operation with motor driven frequency selection.

Below: TEMCO Model 350 AG 350 watts output 6-frequency band switching mobile transmitter, designed for military service aboard trucks.



Hundreds of hand operations enter into the custom-style construction of every TEMCO unit.

Of all these, the last and simplest is the most important: the affixing of the TEMCO name plate, which sets our "hand and seal" to certify that the last detail of perfect workmanship has been patiently and skillfully built in . . . assuring years of dependable service.

Application of the name plate signifies that the job has passed the most exacting inspections and tests imposed by our own engineers . . . and now invites inspection by U. S. Government services, or any other users employing the most critical standards.

TEMCO

RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.

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This TRUSHADE user's stamp of approval is indicative of the way in which leading industrialists everywhere are endorsing our radically different gold-plating procedure.

The TRUSHADE method of gold plating permits trouble-free HEAVY DEPOSITIONS of 24 kt. gold with less waste and with DEFINITE CONTROL and POSITIVE ANALYSIS of the gold and gold alloys solution — (100% ACCURATE ANALYSIS in less than 20 minutes).

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Our Advisory Service will furnish any further facts on request.

Other satisfied users of TRUSHADE



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Providence, R. I.
Attn: Mr. Frank K. Smith

Gentlemen:

We have now used your Tru Shade 24K Gold solution for several months -

We have been gold plating for the past 50 years and in recent years our laboratory has been able to control quality and thickness -

In using your solutions we find that we can plate to these exacting specifications and at a considerable saving under our former costs and eliminating our former difficulty in making such solutions.

We find your method economical and reasonable.

Yours truly,

FOX COMPANY
Since 1862

E. H. Laws, Supt.
E. H. Laws, Supt.

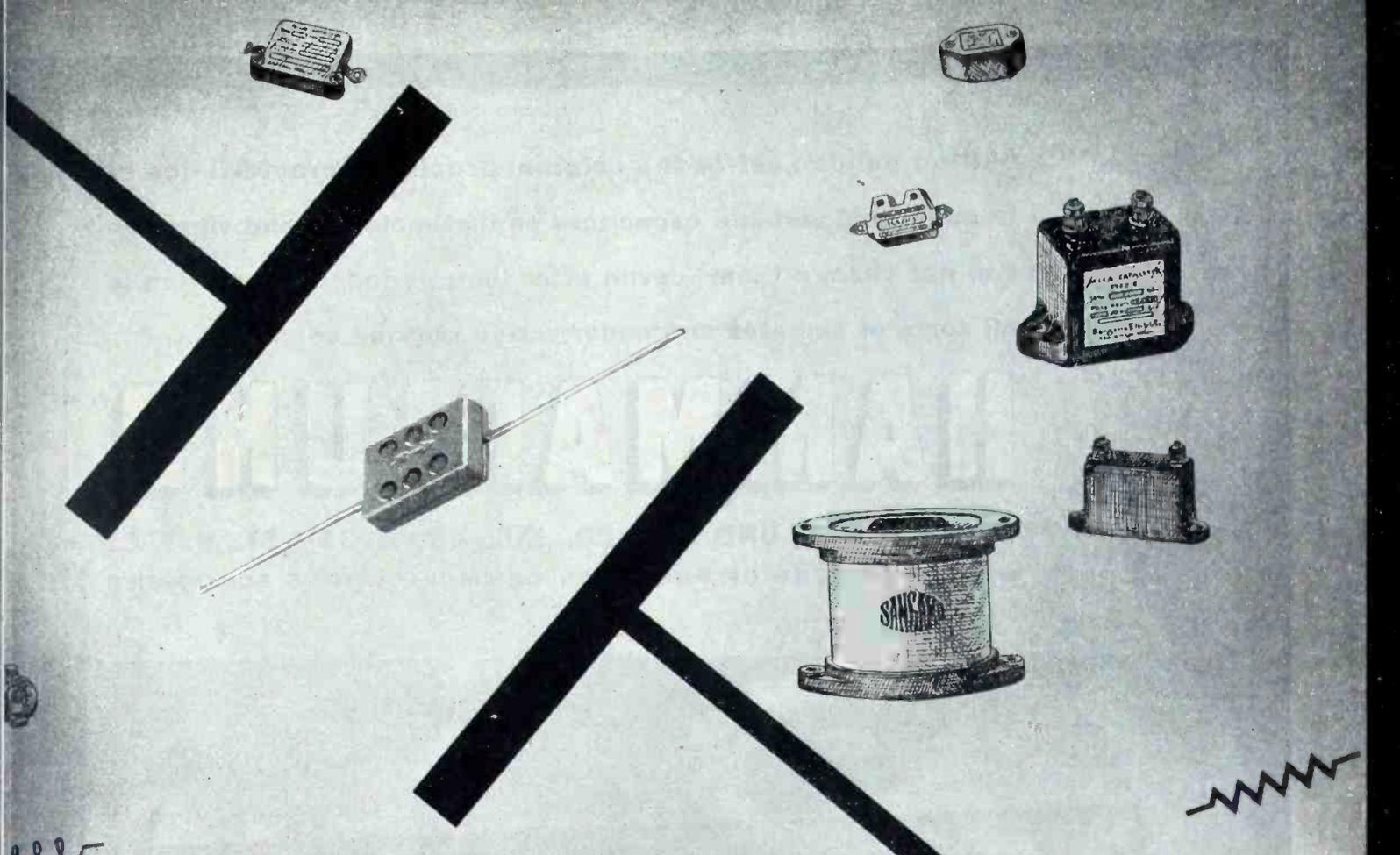
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Smaller size - lighter weight - better operating characteristics - these are the prime requirements of practically all components going into electronic equipment today! The urgent need for communication equipment in locations where cubic content and light weight are of major importance necessitates the use of component parts which conform in every respect to achieve these desired results.

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Sangamo Type K mica capacitors, manufactured to these specifications, are performing faithfully in many thousands communication equipments now in service in all corners of the world.

SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS



Skilled hands *seal-in* the original precise characteristics of Hammarlund variable capacitors so that moisture and vibration can not change them — even after long periods of operation in all sorts of climates and under varied working conditions.

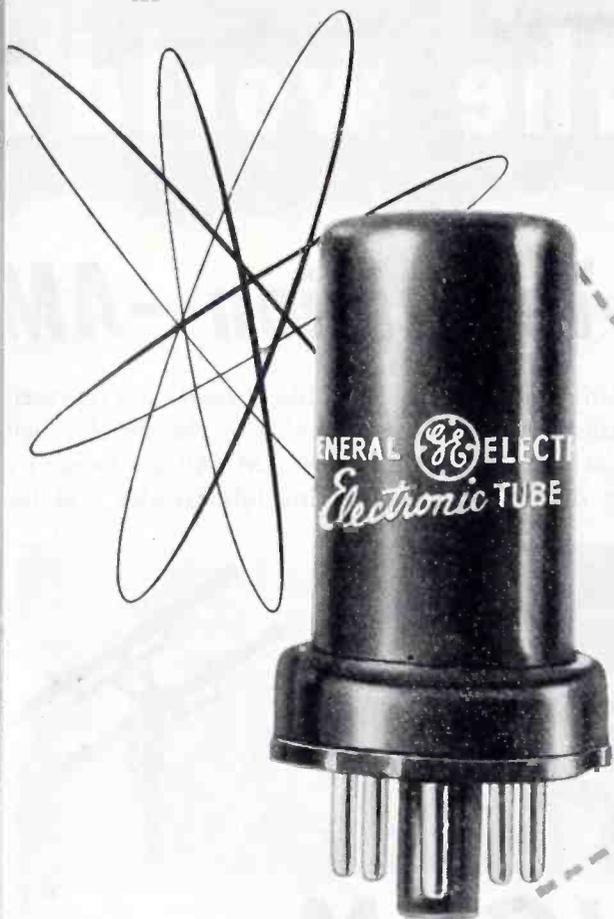


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MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT



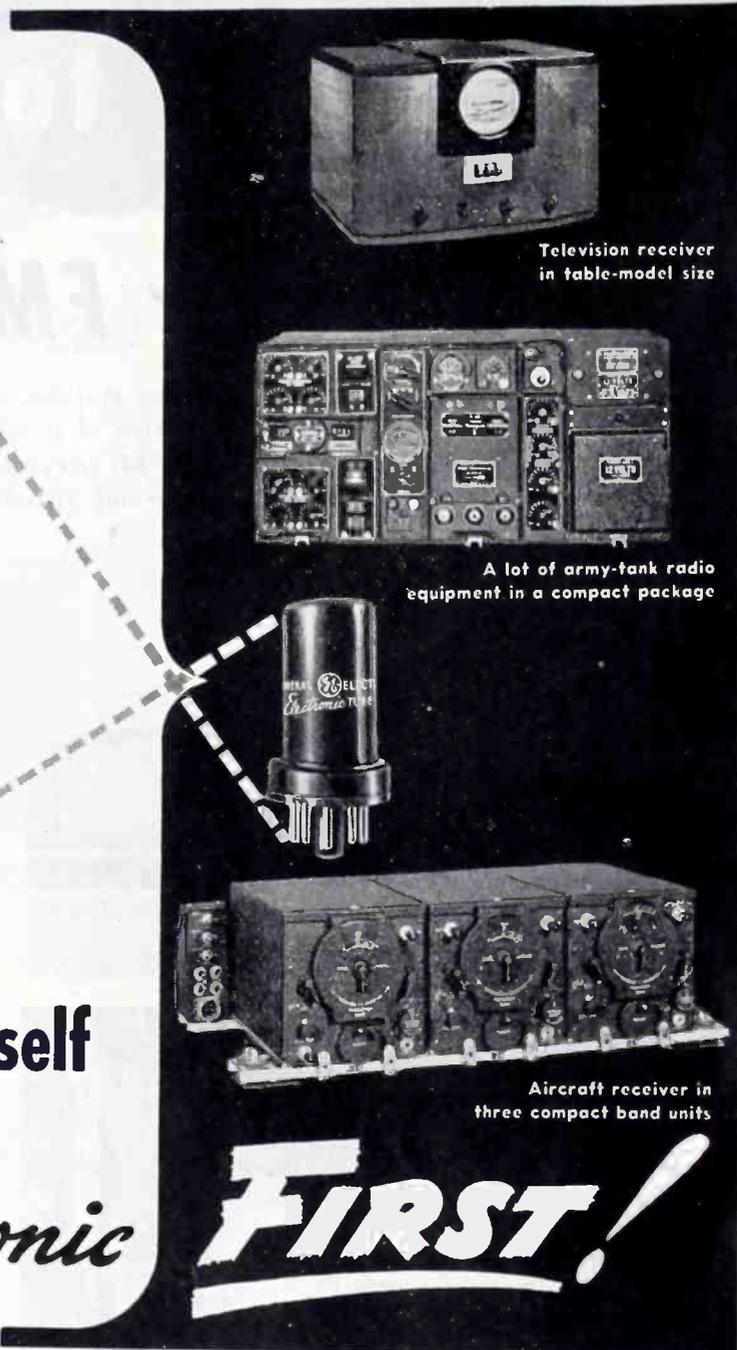


The tube that shields itself another G-E electronic

THE G-E development of the metal receiver tube represented a complete departure in the conception and manufacture of electronic receiver tubes and of parts assembly.

The G-E metal receiver tube not only serves as an "envelope" for the tube elements, but in itself provides the necessary "shielding" to prevent feedback (the electrostatic or electromagnetic influences in circuits which interfere with operation). Thus, the elimination of separate, space-consuming shielding devices permitted circuits to be designed more compactly. This, in turn, made possible the simplification and the smaller size of receivers — not only for "consumer" uses, but importantly for aircraft, tank, lifeboat and other vital needs.

General Electric progress during all the years of radio history has been a succession of electronic-



Television receiver
in table-model size

A lot of army-tank radio
equipment in a compact package

Aircraft receiver in
three compact band units

FIRST!

tube "firsts." You may be sure that *all* G-E tubes — transmitting or receiving — possess everything that electronic research and engineering have uncovered . . . and that they have the most exacting construction, highest efficiency, and longest serviceable life the world's finest tube factory can produce.

G-E TUBES ARE "FIRST" IN INDUSTRY, TOO! For example, General Electric pioneered in the application of the phototube in commercial talking moving pictures. G. E. has also contributed to the designing of sorting, inspection, registering, counting and other apparatus employing the light-sensitive characteristics of the phototube.

FREE BOOK, "HOW ELECTRONIC TUBES WORK." Address *Electronics Dept., General Electric, Schenectady, New York.*

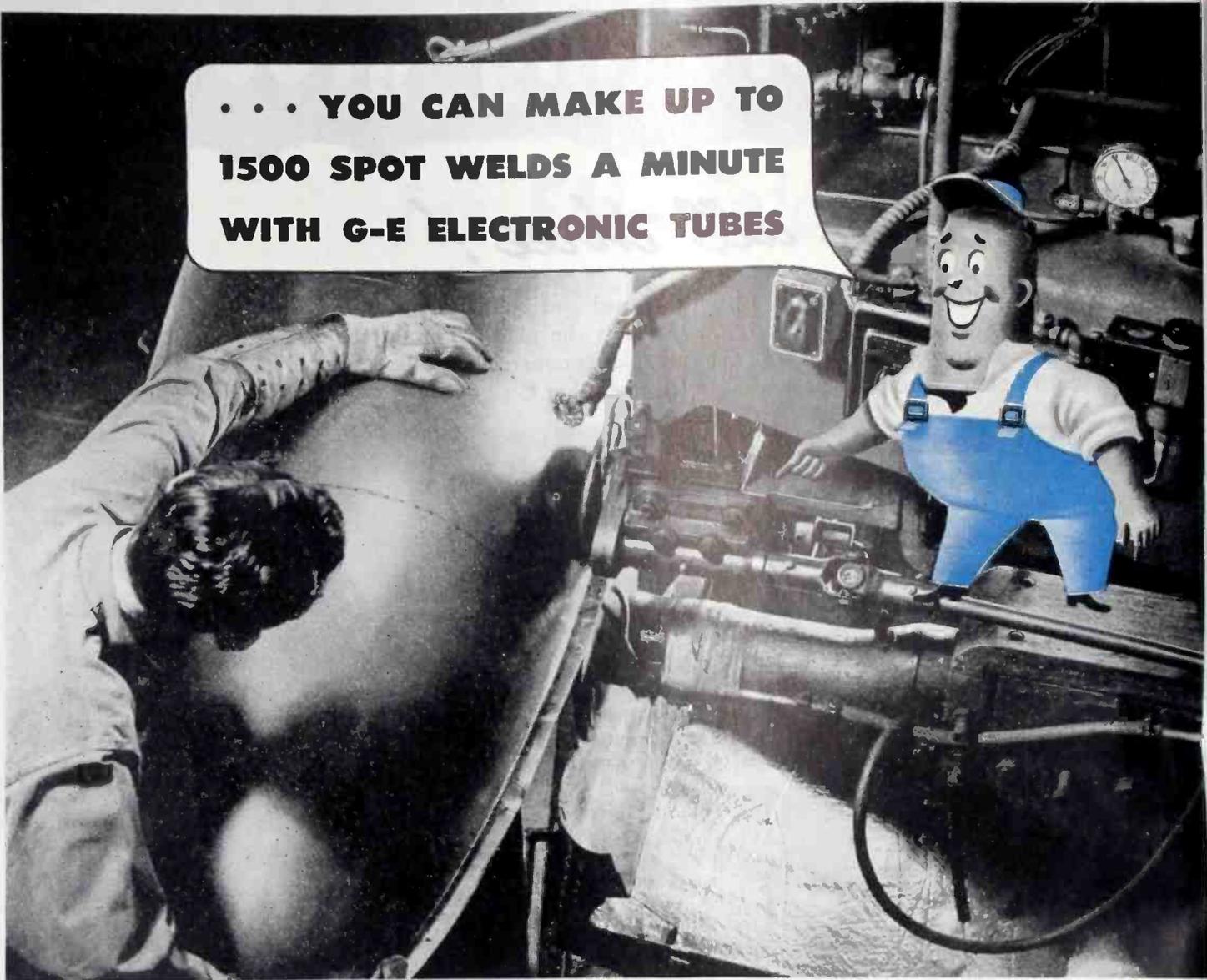
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GENERAL ELECTRIC

181-C7-8850

**... YOU CAN MAKE UP TO
1500 SPOT WELDS A MINUTE
WITH G-E ELECTRONIC TUBES**



**HIGH-SPEED PRECISION WELDING
IS MADE POSSIBLE BY THE G-E
IGNITRON AND THE G-E THYATRON**

IN THE photograph above, a droppable fuel tank for aircraft is being seam-welded with the aid of G-E electronic tubes, at a production rate far in excess of what was considered possible only a short while ago.

The heart of the welding control equipment is the G-E electronic tube — the steel-clad ignitron, which provides the high current demanded; and the thyatron, a precision timer, which controls the passage of current as seam

welds are spotted at any desired distance, overlapped, or brought into a solid line. Seam welds can be made at speeds up to 1500 or more welds a minute.

Thyatron control is especially valuable for spot or seam welders because it *automatically* opens and closes the circuit at precisely the same point each time on the a-c supply voltage wave. This minimizes *transient* currents, the cause of non-uniform welds.

Advantages of the electronic-tube method over mechanical methods are: Improved quality of welds; reduced voltage regulation; low maintenance cost; smooth heat adjustment over a wide range.

There is a complete line of G-E electronic tubes for innumerable industrial jobs; and near you is a G-E electronic-tube distributor who is prepared to fulfil your requirements.

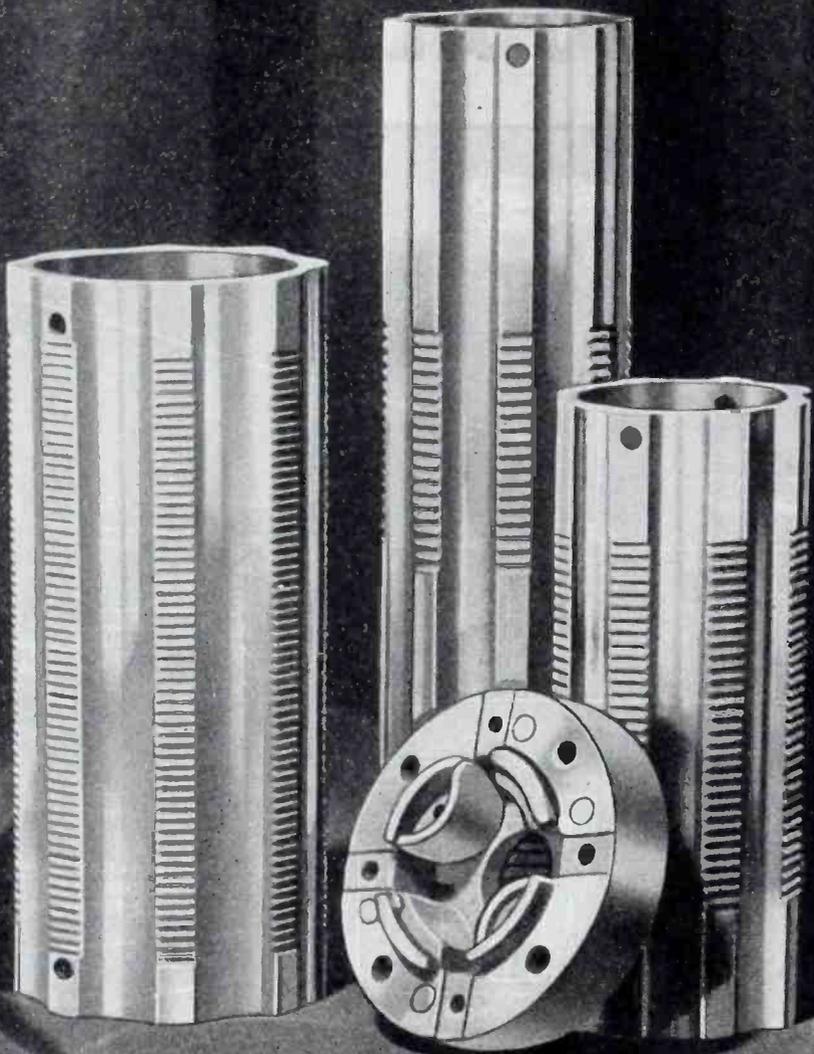
"HOW ELECTRONIC TUBES WORK"

This booklet will be mailed to you on request—without charge. Address *Electronics Department, General Electric, Schenectady, New York.*

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GENERAL  ELECTRIC
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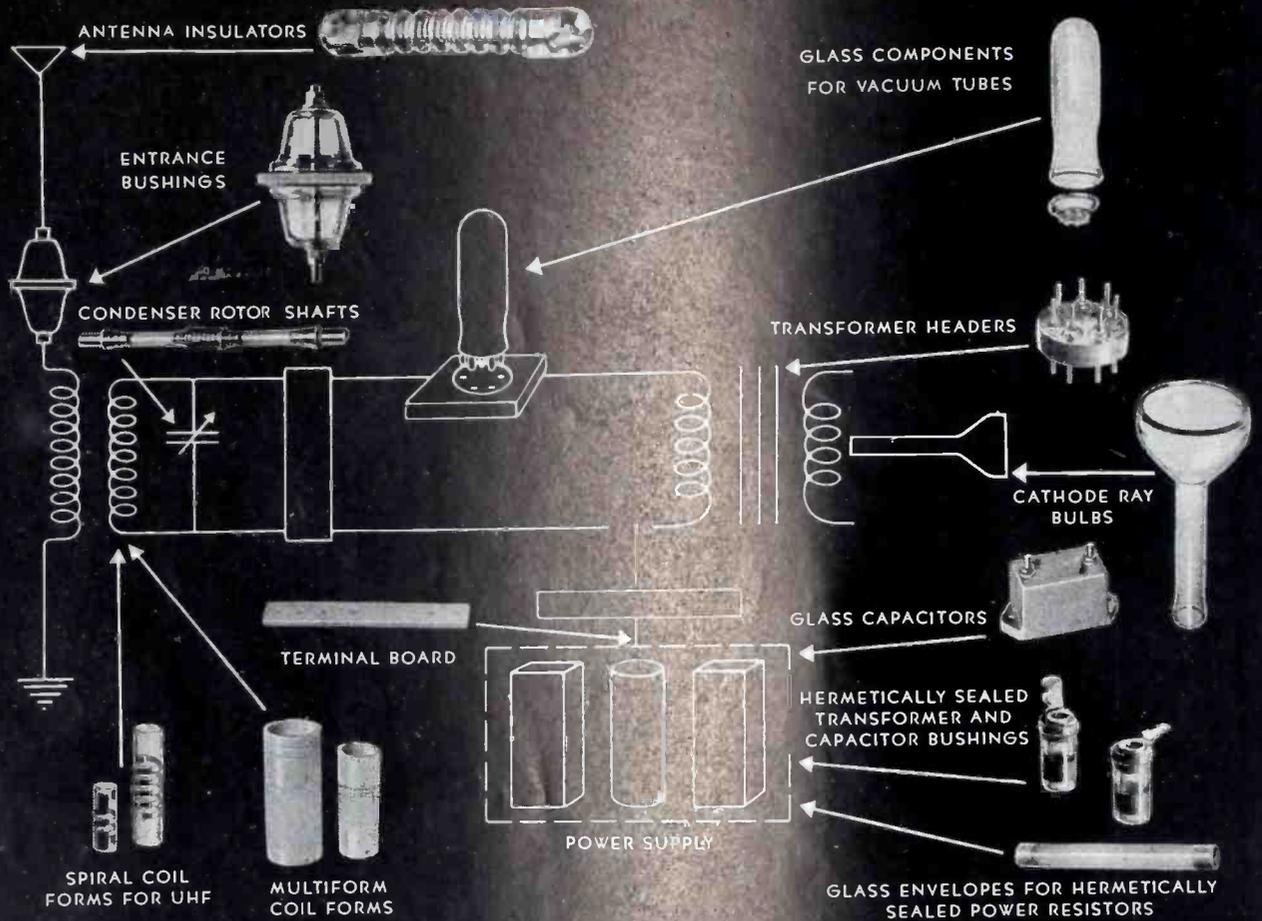


Fine ceramics by


Centralab

Division of GLOBE-UNION INC., Milwaukee

ARE YOU LETTING GLASS HELP YOU ALL IT CAN?



IT wouldn't be surprising if you aren't familiar with everything glass is doing in electronic equipment today. Progress has been rapid. In the above "circuit", for example, you'll find it on the job in (twelve) vital places. At Corning right now we're making a lot of other electronic glassware that we can't show. After the war we'll tell you all about it.

It's no accident that a major part of the electronic glassware in use got its start at Corning. We've dug in on some tough ones and ferreted out solutions. They told us we couldn't solder metal to

glass — they needed glasses with a coefficient of expansion practically equal to that of fused quartz — they needed something to take the place of mica in capacitors — Corning Research found the answers to these and many other electronic problems.

Our 250 glass experts—the men behind "Corning Research"—our facilities and all our knowledge of glass are at your service. Write for a copy of an informative new booklet "There Will Be More Glass Parts in Postwar Electrical Products." Address Electronic Sales Dept. E-10, Bulb and Tubing Division, Corning Glass Works, Corning, N. Y.

CORNING
means
Research in Glass

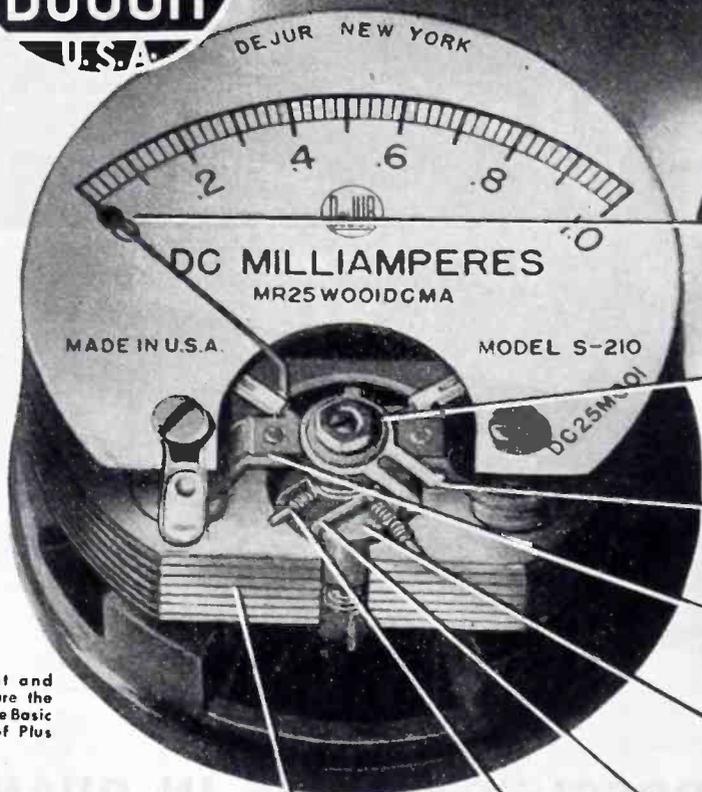
Electronic Glassware



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ELECTRICAL INDICATING INSTRUMENTS



Magnet Movement and Bracket Illustrated are the S-210 0-1 Milliamper Basic Design—Accuracy of Plus or Minus 2%.

- Moulded Phenolic Base Opens in Front for Easy Access To Movement
- Anodized Coil Frame
- Matched Torque to Minimize Temperature Effect
- All Brass Scale Plate
- Static Grounding Brush
- Scale Plate Lacquers Are Fumeproof
- Strong, Moulded Phenolic Case

● POINTER

● JEWELLED BEARINGS

● ZERO ADJUSTING LUG

● STURDY AIRCRAFT TYPE BRACKET

● CORE

● MOVING COIL

● CHROME STEEL MAGNET PROTECTED BY CADMIUM AND TIN PLATINGS

● BERYLLIUM COPPER BALANCE WEIGHTS

Better Balancing

... and a uniform magnetic flux around the moving coil, eliminate possibility of calibration error.

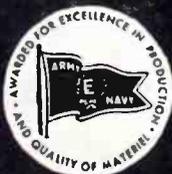
Longer Pivot Axis

... permits a more accurate adjustment of jewels and pivot assembly. More easily accessible, too, in event of repair or servicing.

Superior Magnetic Materials

... Alnico and cobalt are used in conjunction with soft iron pole pieces, thus assuring high torque, fast response and improved performance.

Keep Buying War Bonds

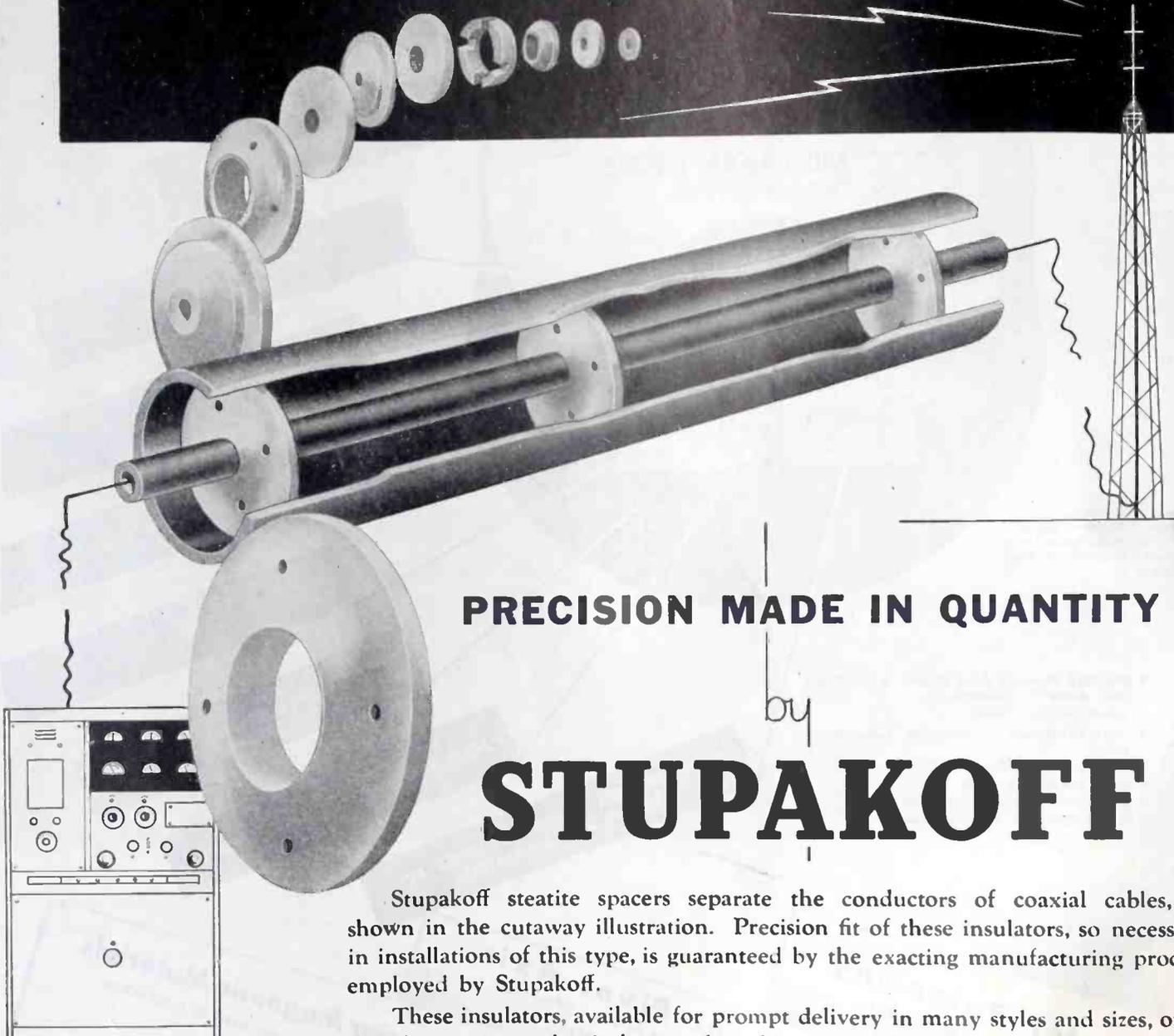


All DeJur Electrical Indicating Instruments are manufactured in strict conformance with American Standards Association specifications. Additional technical information will be supplied upon request.

DeJur-Amsco Corporation

GENERAL OFFICE: NORTHERN BLVD. AT 45th ST., LONG ISLAND CITY 1, N. Y.

Steatite Insulators for **COAXIAL TRANSMISSION LINES**



PRECISION MADE IN QUANTITY

by
STUPAKOFF

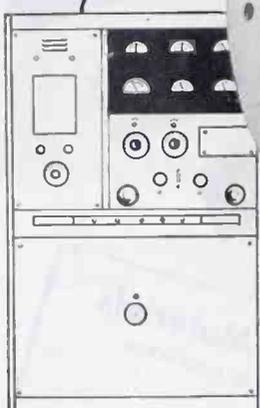
Stupakoff steatite spacers separate the conductors of coaxial cables, as shown in the cutaway illustration. Precision fit of these insulators, so necessary in installations of this type, is guaranteed by the exacting manufacturing process employed by Stupakoff.

These insulators, available for prompt delivery in many styles and sizes, offer the ultimate in mechanical strength and low power loss characteristics.

Stupakoff, backed by two generations of engineering and manufacturing experience, produces a complete line of ceramic insulators made of steatite and other materials.

Write today for dependable assistance in developing correct insulation for your electronic apparatus. Problems involving insulators—whether specialized or standard—will be given prompt attention by our Technical Staff.

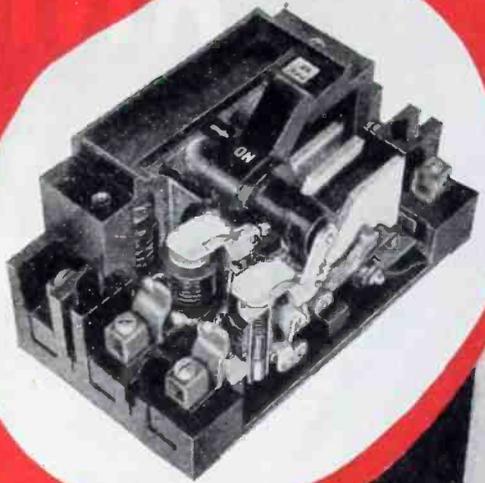
Do More Than Before—Buy EXTRA War Bonds



STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Ceramics for the World of Electronics

ACTUAL SERVICE Is The Real Test For **HEINEMANN** *MAGNETIC CIRCUIT BREAKERS*



*The Test Behind
The Breaker Makes
The Breaker Stand
The Test!*



The above photograph shows Heinemann Circuit Breakers on the final time test. Breakers are manufactured with time delays closely matched to customer's specification. Each breaker is tested on at least three points of its time delay curve to insure that the time delay stays within the curve limits specified.

Other tests include high potential tests, trip point tests, time delay tests, vibration tests, etc. Breakers are designed to carry full load continuously and to trip at 8 to 10 times full load instantaneously regardless of ambient temperature. Send for bulletin giving time delay curve, mechanical details, and engineering data.

HEINEMANN CIRCUIT BREAKER CO.

Subsidiary Heilmann Electric Co., Est. 1888

97 PLUM STREET

TRENTON, N. J.

ANNOUNCING*



SPRAGUE

Ceroc 200

**A high-temperature (200° C.) ceramic insulation
for copper, nickel, and other wire**

*We use the word "Announcing" advisedly. Although this is its first public announcement, Sprague CEROC 200 is by no means a new or untried development. Many engineers are already familiar with it. Many have long been using it on restricted war developments on

which details cannot yet be announced. So far-reaching are its possibilities for such a wide variety of electrical products, however, and with our production facilities being steadily and materially expanded we take this means of bringing it to general trade attention.

† T. M. REG. U. S. PAT. OFF.



Ceroc 200

INORGANIC INSULATION FOR COPPER AND OTHER WIRE

PERMITS 200° C. CONTINUOUS OPERATION FOR MANY TYPES OF ELECTRICAL EQUIPMENT

A CLASS C INSULATION MATERIAL



CROSS SECTION
The extreme uniformity of CEROC 200 makes for smooth, level winding. The thinness with which it may be deposited on the wire saves space.

Culminating seven years of continuous research and development by the Sprague engineering organization, CEROC 200 now paves the way for greatly increased efficiency, smaller sizes, and lighter weight for a wide variety of electrical equipment.

Sprague CEROC 200 is a ceramic (inorganic) insulating coating thinly deposited on copper, nickel, and other types of wire, and permitting much higher continuous operating temperatures than are possible with ordinary Class A insulations such as enamels, varnishes, and other organic materials. Applied to copper wire, it permits of a conservatively rated 200° C. continuous operating temperature as compared to the present limit of 105° C. for Class A materials. Thus, by designing electrical equipment to utilize the full maximum operating temperature of this new wire coating, a very substantial increase in volt-ampere rating can be obtained. We believe that CEROC 200 meets all requisites of a Class C insulating material under A. I. E. E. standards.

THERMAL CONDUCTIVITY: Coils wound with CEROC 200 dissipate heat rapidly. There is little or no tendency toward development of hot spots which might nullify a big percentage of the high-temperature gain that would otherwise be expected. Thus, the high-temperature advantages of CEROC 200 are real and not apparent.

SPACE FACTOR is extremely good. Typical percentages of copper area to total cross-sectional area of finished wire are 96% for AWG #21 wire, and 95% for #24 wire for CEROC 200 by comparison with only 69% and 59% respectively for other insulations that might be used for high-temperature applications. Moreover, CEROC 200 coating is extremely uniform, thus making for smooth, level winding. The preferred coating thickness is 1/4 mil., and the following characteristics are based on wire so coated:

MAXIMUM STABLE TEMPERATURE for continuous operation—200° C.

VOLTAGE BREAKDOWN between two wires of a twisted pair 4" long:
Standard condition (25° C.)—300 v. A.C.

Humid condition (95% relative humidity)—300 v. A.C.

Hot condition (200° C.)—300 v. A.C.

LEAKAGE between two wires of a twisted pair, 4" long, at 95% relative humidity is greater than 100,000 megohms.

FLEXIBILITY by bending: 16% elongation.

ABRASION RESISTANCE: Average 16-18 scrapes at 200 G. weight on G.E. abrasion tester for #25 AWG wire having the preferred 1/4 mil. coating thickness. On wire sizes smaller than #25, this average is slightly less, and on larger than #25 wire, it is somewhat more.

WIRE SIZES: Although CEROC 200 is constantly being adapted to new uses, the present preferred ranges for coated wire are as follows:

Copper wire—from 3 to 30 mils (#40 to #21 AWG).

Nickel wire—from 1 1/2 to 12 mils (#46 to #28 AWG).

WINDING CHARACTERISTICS: CEROC 200 is sufficiently flexible to present no winding difficulties that will not be far more than compensated for by its tremendous high temperature and space advantages. In general, round coils can be wound satisfactorily by existing methods. Slight modifications in winding technique may prove necessary, however, in the case of rectangular coils or motor armatures.

Although costs on CEROC 200 are being steadily revised downward, as a result of greatly increased facilities, it should be borne in mind that this material was not designed to compete on applications where conventional organic insulations are giving satisfactory service. Rather, it is intended for those applications where a substantially higher temperature insulation combined with space- and weight-saving factors more than justify a somewhat higher price for the CEROC 200 insulation that makes them possible.

SAMPLES

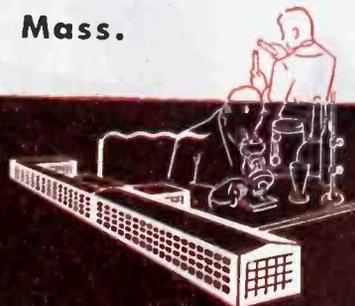
CEROC 200 is by no means a new or untried development. For more than a year, large quantities of CEROC-insulated wire have been supplied for important war applications of the most exacting sort. Thus, although production facilities are being steadily increased, it is still difficult to supply generous samples of specific wire sizes to all who might be interested. As far as possible, however, we will gladly supply small quantities of available sizes to large users who want to test its far-reaching possibilities in connection with their products at a later date when full and prompt deliveries are possible.

SPRAGUE ELECTRIC COMPANY, North Adams, Mass.

(Formerly Sprague Specialties Company)

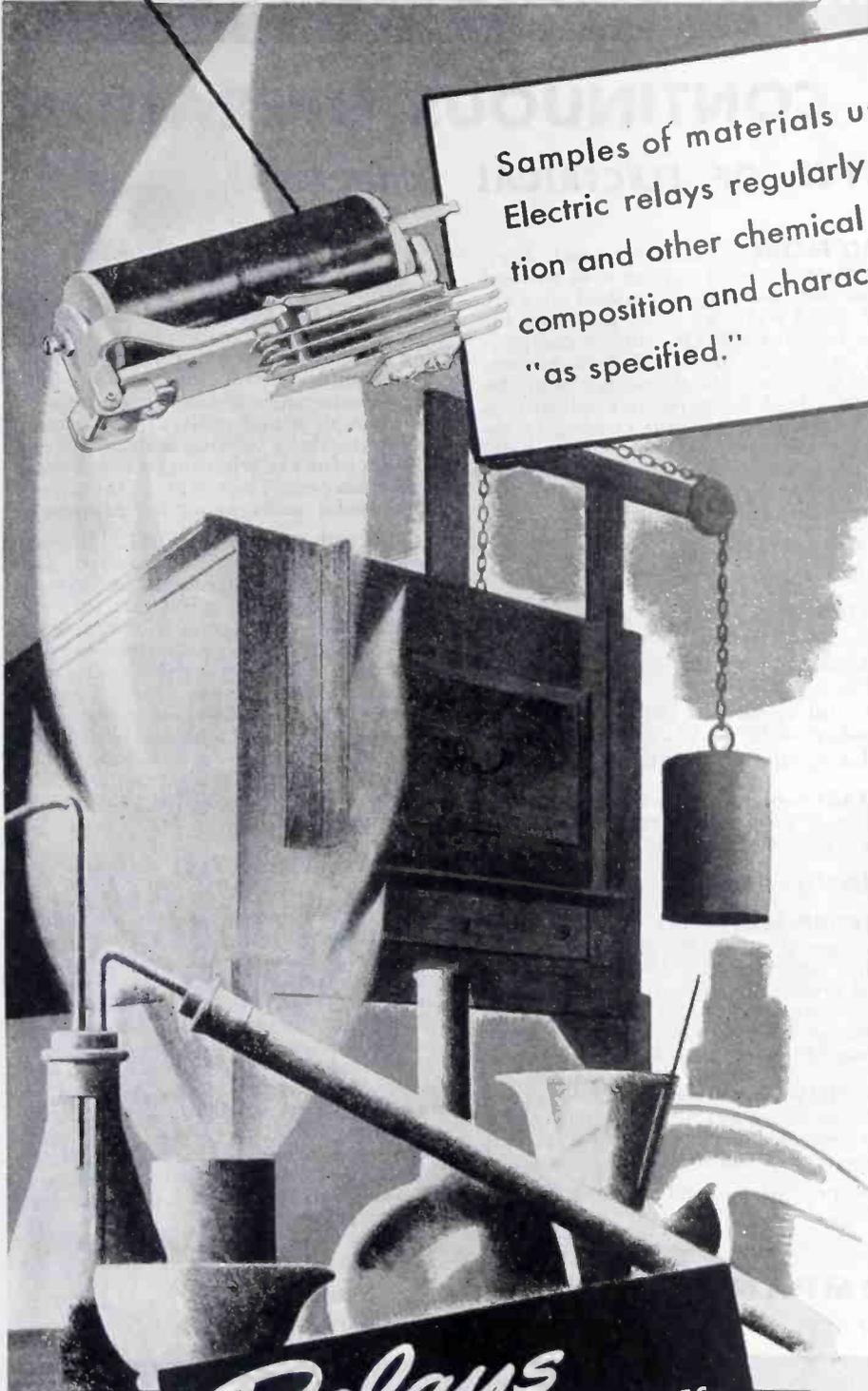
SPRAGUE

CAPACITORS • KOOLOHM RESISTORS • CEROC INSULATION



† TRADEMARKS REGISTERED U. S. PATENT OFFICE

"The Heats On" To Verify Relay Material Composition



Samples of materials used in Automatic Electric relays regularly undergo combustion and other chemical tests to insure that composition and characteristics are exactly "as specified."

It may seem a simple matter—this job of selecting the right materials for making relays; but—

Automatic Electric designers know better. They know that correct design is only the beginning—that materials must also meet exacting standards, or performance will suffer. That is why they insist that quality control must begin in the laboratory.

When you need relays, call in the Automatic Electric field engineer. He can show you how quality pays, in longer life, better performance. In the meantime, for a preview of the Automatic Electric line, write for Catalog 4071.

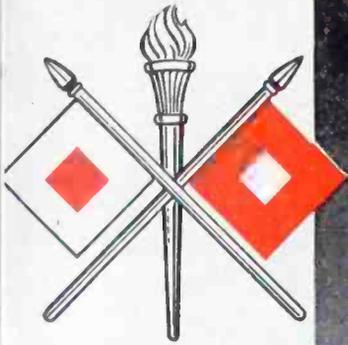
Relays
AND OTHER CONTROL DEVICES
by **AUTOMATIC
ELECTRIC**

★
AUTOMATIC ELECTRIC SALES CORPORATION
1033 WEST VAN BUREN STREET • CHICAGO 7, ILLINOIS
In Canada: Automatic Electric (Canada) Limited, Toronto



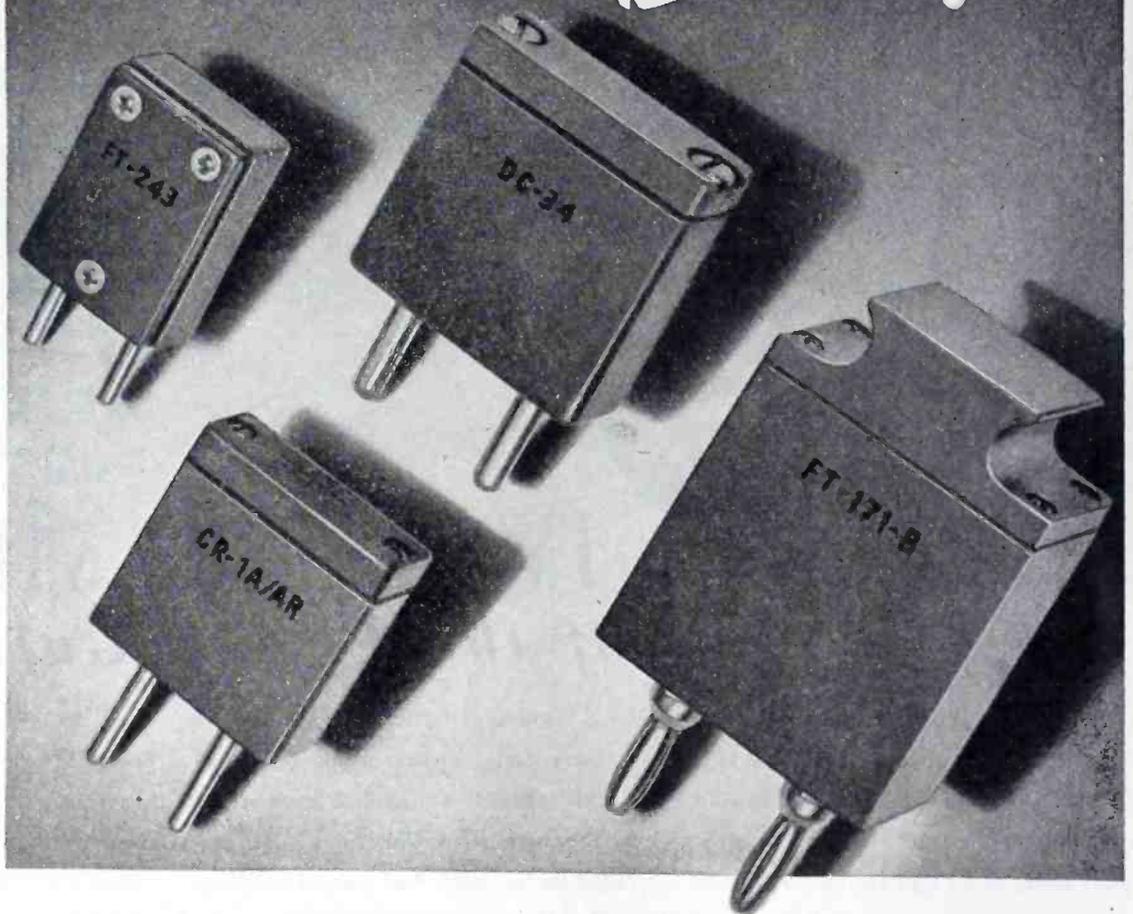
PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED

SIGNAL CORPS EQUIPMENT



Four basic controls

by *Bliley*



All helping to "get the message through" . . .

all precision proved in the tradition of

BLILEY CRYSTALS



Bliley
CRYSTALS

Do more than before . . .

buy extra War Bonds

BLILEY ELECTRIC COMPANY • UNION STATION BUILDING • ERIE, PENNSYLVANIA



INCREDIBLE SALVAGE

The Case of the Flying Gull . . .

During the storm season of 1942, *The Flying Gull* ran into heavy seas in the Gulf of Mexico.* Running before a terrific wind, she all but made port. Then, just as she was putting about near Hunter's Point, she shipped a gigantic wave and foundered. All hands were saved. But *The Flying Gull* rested in eight fathoms of Gulf water.

Salvage operations were started. Later in 1942, when *The Flying Gull* was in the dock and her electrical equipment ripped out, an amazing thing occurred. George Long, of The Harris Salvage and Drydock Company of Galveston, put the Thermador transformer equipment on a shelf in the sunshine—mentally assigning it to the scrap metal drive. Three days later, out of curiosity, he hooked the transformers onto a testing bench and flipped on the current. To his amazement, they still showed signs of life. He then ran standard tests. To his further astonishment, all twelve of the transformers were not only working—they

were working perfectly.

Harvy Stark, owner of the boat, had already ordered a complete new set of transformers from Thermador. He cancelled the re-order. And today *The Flying Gull* sails with her original Thermador transformers. Not designed for the briny deep—but they could take it!

Such stories of plus performance are not accidents, for Thermador transformers are

built to perform beyond normal expectations. They are completely manufactured—not just assembled—under one roof on a vast array of modern precision equipment. They are made *only* from the finest materials, engineered by men of broad experience. The result is not alone quality but *quality in quantity*. If that meets your specifications, better discuss transformers with Thermador.

**THERMADOR
TRANSFORMERS**
DEFEAT HEAT • COLD • HUMIDITY

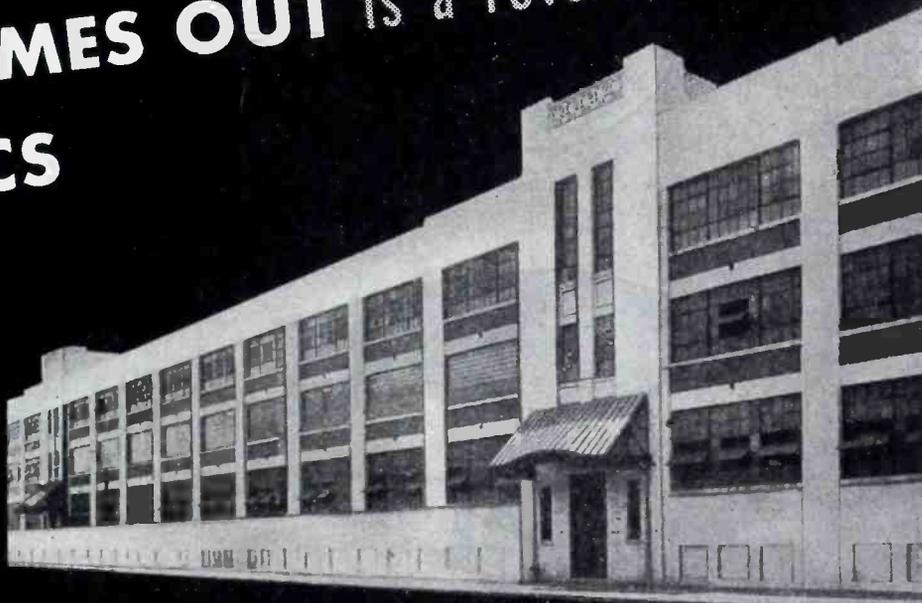


**An actual case history from Thermador files; however names, dates, and location have been altered. Buy MORE War Bonds.*

THERMADOR ELECTRICAL MANUFACTURING COMPANY
5119 SOUTH RIVERSIDE DRIVE • LOS ANGELES 22, CALIFORNIA

what goes on in here is a military secret
WHAT COMES OUT is a revelation in
ELECTRONICS

at its
working best



- LABORATORY
- DESIGN
- DEVELOPMENT
- MANUFACTURING

Housed in this block-long Sherron Electronics building is a busy laboratory in which many valuable discoveries have come to light. Here has been developed the widely used Sherron Test Units that are serving many of America's foremost electronics manufacturers in maintaining the quality control so vital to the integrity of their products. Here, working full time, day and night, a corp of electronics engineers are blazing new trails. Here a hard-working staff of technicians and scientists are evolving new applications of the amazingly versatile tool that is electronics.

*Sherron
Electronics*

We invite correspondence with manufacturers who are thinking in terms of post-war electronics. They will find our specialized experience, resources and skills of real value.

SHERRON ELECTRONICS CO.
1201 Flushing Avenue
Brooklyn 6, N. Y.

Where the Ideal is the Standard, Sherron Test Units Are Standard Equipment



BRINGING BOMBERS HOME!

Radio direction-finders, designed and manufactured by Press Wireless Inc., are now in war-time service throughout the world, helping to guide bombers and other aircraft safely home after completion of their missions.

Production of units of this type is part of the Press Wireless program which includes the manufacture not only of radio communications equipment of the highest efficiency but also of a diverse range of radio instruments and installations for ground use in modern aviation.

Press Wireless recognizes that communications and aviation go hand in hand and invites inquiries now concerning the products it plans to have available when peace comes.



Awarded to our Hicksville, Long Island Plant for outstanding Achievement in War Production

PRESS WIRELESS, INC. IS DEVELOPING OR MANUFACTURING

- HIGH POWER TRANSMITTERS
- DIVERSITY RECEIVERS
- AIRCRAFT AND AIRFIELD RADIO EQUIPMENT
- RADIO PRINTER SYSTEMS
- MODUPLEX UNITS "TRADEMARK"
- CHANNELING DEVICES
- RADIO PHOTO TERMINALS
- FACSIMILE MACHINES

AND OTHER TYPES OF RADIO AND COMMUNICATIONS EQUIPMENT

Sales Office, Manufacturing Division
1475 BROADWAY, NEW YORK 18, N. Y.

PRESS WIRELESS, INC.

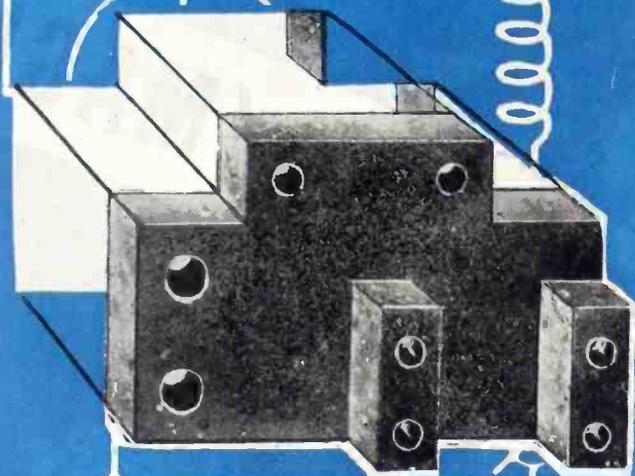
Executive Offices
435 N. MICHIGAN AVENUE, CHICAGO

RIO DE JANEIRO • MONTEVIDEO • BERNE • SANTIAGO DE CHILE • NEW YORK • CHICAGO • LOS ANGELES • LONDON • HAVANA

MYCALEX 400

(PATENT PENDING)

The 'Last Word' in Low-Loss Insulation — Perfected after 25 years of Research Leadership



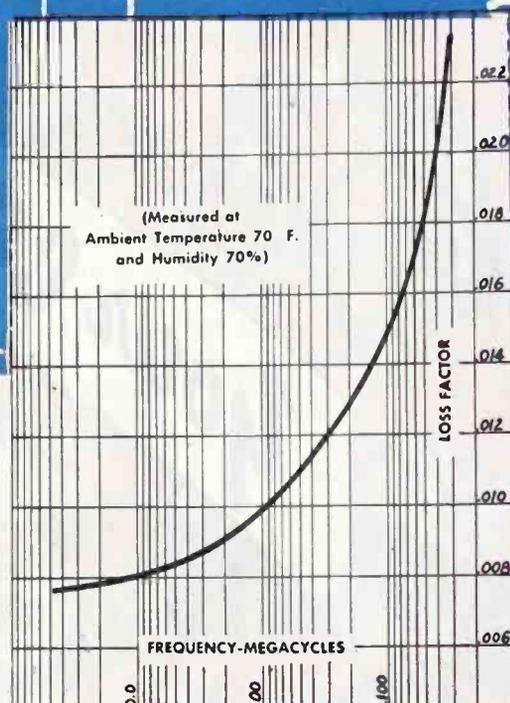
FITS PERFECTLY Into High Frequency Design

AT last designers of tomorrow's high frequency apparatus have an improved type of glass-bonded mica insulation to specify where new advancements in low-loss characteristics are desired, as in ultra high frequency applications.

Behind this new product is a history of 25 years of research leadership. Just as the original MYCALEX, developed by the MYCALEX (Parent) Company of Great Britain 25 years ago, was a vast improvement over other ceramics, so the new MYCALEX 400, developed exclusively by the MYCALEX Corporation of America, is a comparable advancement over all early forms of glass-bonded mica.

MYCALEX 400 meets government specifications for L-4 characteristics, by virtue of its pronounced low-loss factor of 0.013 at 1 megacycle. Its surface resistivity is 300,000 megohms. Its power factor is 0.0018 at 1 megacycle; in accordance with American War Standard C-75.1-1943 (Jan. 1-10). Its dielectric constant is unchanged from 50 kilocycles to 10 megacycles. MYCALEX 400 can be machined with greater precision . . . drilled, tapped, milled, sawed, turned and threaded.

Improved postwar h-f equipment deserves this newly refined and perfected electronic insulation. Let us supply your stock requirements in sheets and rods; or have us fabricate component parts to your specifications. Write for full details and samples.



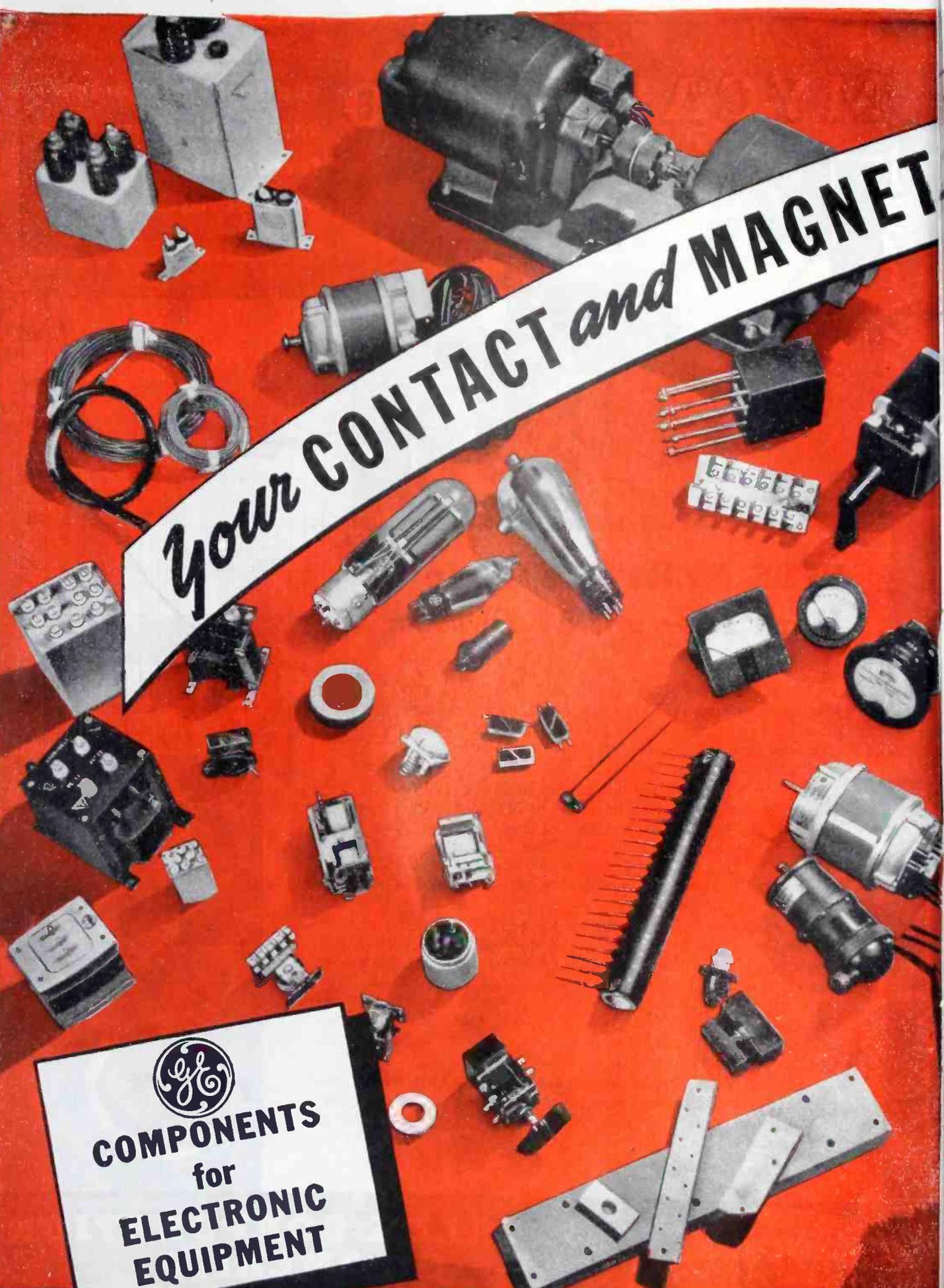
MYCALEX CORPORATION OF AMERICA

"OWNERS OF 'MYCALEX' PATENTS"

CLIFTON,
NEW JERSEY

Executive Offices: 30 ROCKEFELLER PLAZA
NEW YORK 20, N. Y.

Your CONTACT and MAGNET




COMPONENTS
for
ELECTRONIC
EQUIPMENT

BUY ALL THE BONDS YOU CAN—AND KEEP ALL YOU BUY

PROBLEMS

pre-solved!

Switchettes and Alnico magnets afford examples of how G-E components save designers' time, make for better performance

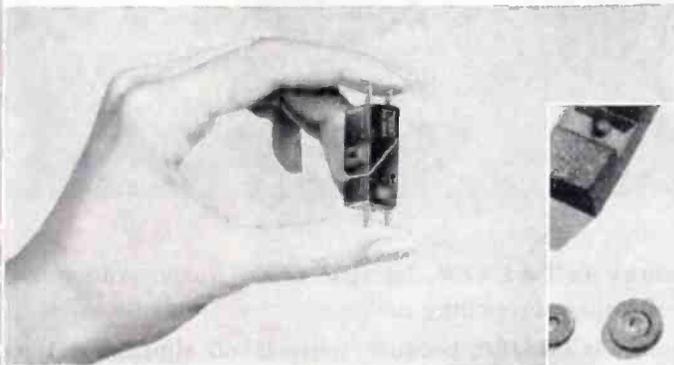
● If you're puzzling over how to get the switching functions you want into the limited space you'd like to allow, the chances are that you'll find your answer *ready-made*—in the G-E Switchette.

Again, if yours is the problem of applying permanent magnets (perhaps of intricate shapes) in restricted space, you may find your problem *solved in advance*—by G-E Alnico magnets.

These are but two of many examples of G-E electronic components that lift a big burden of detail from de-

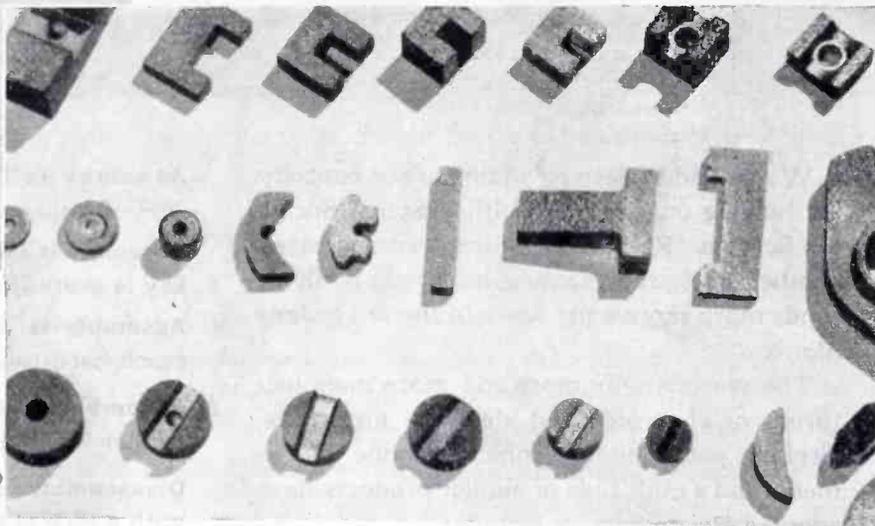
signers' shoulders, and give greater latitude in the design of new equipment. Each of these components is the product of close co-operation between designers—at G.E. and in the electronics industries. Each is precision-built. Each has proved its ability to maintain specified performance characteristics under severe service conditions.

In selecting components from General Electric's extensive line, you can count on practical help from qualified G-E representatives. Located in principal U.S. cities, these men will gladly co-operate with you on both application and procurement problems. Call on them through the G-E office nearest you. *General Electric Company, Schenectady 5, N. Y.*



THE G-E SWITCHETTE

Smaller than a woman's thumb, the switchette shown weighs only 9 grams; yet it can handle up to 10 amperes at 30 volts a-c, or 10 amperes at 24 volts d-c. Low-inertia moving parts, high contact force, and double-break construction assure positive action, even in the face of the severe vibration encountered in combat aircraft. Actuation can be manual or mechanical, as by a cam, lever arm, or bellows. Switchettes are available in such a variety of contact forms and terminal arrangements that many perplexing contact problems are generally "licked to start with." Bulletin GEA-3818B describes more than 100 types and arrangements. Ask for your copy.



SINTERED ALNICO MAGNETS

Alnico magnets, of which there are several types, provide more external energy for a given volume than any other permanent-magnet material, more stored energy per dollar. Alnico is also more resistant to stray magnetic fields, temperature extremes, and vibration. Sintered Alnico II, because of its compactness, stability, and uniform flux distribution, facilitates the design of precision devices of small size. The sintered-alnico process employed by G.E. is a "natural" for large-scale, close-tolerance manufacture of both simple and complex shapes—for hearing aids, electronic measuring equipment, microphones, etc., and for numerous applications in connection with electronic tubes. Ask for Bulletin GEA-3682A.

GENERAL  ELECTRIC

642-4

Our answer to your enthusiasm for the tightest-setting small screw on the market:



We've had to keep on adding to our capacity for turning out Bristo Multiple-Spline Socket Set Screws. Recently, facilities were increased another 25%, representing hundreds of thousands more screws per week *in the wire sizes alone*.

The reasons why more and more manufacturers of electronic and electrical apparatus, airplane parts, photographic, scientific instruments and a multitude of similar products have adopted Bristo Screws include:

Assembly is FASTER, because of the easier transmission of rotary wrenching power.

Assembly is EASIER, because there is no slippage — the key is geared to the screw.

Assembly is SIMPLER, because Bristo screws easily reach hard-to-reach places.

Assembly is TIGHTER, because the screw can be turned farther without bursting or rounding out.

Disassembly is QUICKER, because the screw releases with a flick of the key — without socket damage.

Why "BRISTO" Means "TIGHTER"

No expanding pressure; the key pulls the screw around.



154 Bristol Road, Waterbury 91, Conn.

BRISTO MULTIPLE-SPLINE SOCKET SET SCREWS

GEARED TO THE KEY—
FOR FASTER, EASIER,
TIGHTER SETTING



THERE IS NOTHING TO DO ABOUT A WAR EXCEPT WIN IT!

The purpose of this advertisement is NOT to brag about Thordarson's part in the war effort. While patriotism in a person or company may be something to be proud of, our own feeling is that it should not be exploited. Expressing patriotism in America is not even a duty; rather, it is a privilege . . . happily one that is understood and appreciated by the majority.

That is why, for nearly 3 years, Thordarson has talked little about the war and war production . . . except to make the bare statement that we were busy supplying materials for the armed forces.

Regardless of all this, we do think the time is now propitious to give a few more details as to what we are thinking and doing.

When war came, we were one of the first companies to be chosen for front-line production duty. The need was urgent . . . the demands were great. As Americans, we were glad wholeheartedly to tackle the job assigned to us.

Early and late . . . day and night . . . Sundays and holidays, we have continued to devote all of our efforts, 100% to winning the war. We have kept "eyes front" on this one task. We have had to forget, for the moment, personal considerations of "good business" . . . on occasion we have even had to turn down old and good friends who needed this or that which, under ordinary conditions, we would have been tickled to death to supply.

The time will come . . . it's coming shortly, we feel . . . when we again can think first and foremost of supplying civilian needs. That will be a far happier day for us than it could possibly be for you, no matter how much you have needed material you were unable to secure.

But meantime, the war goes on . . . and we, in our small way, must continue to stand guard at our appointed post until the "at ease" command is given. As we said in the beginning: THERE IS NOTHING TO DO ABOUT A WAR EXCEPT WIN IT!



THORDARSON

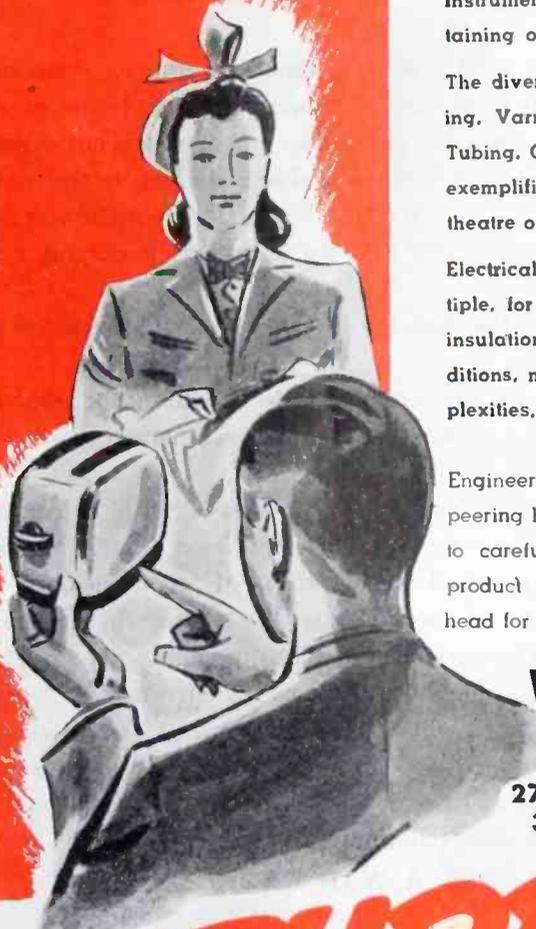
TRANSFORMER DIVISION
THORDARSON ELECTRIC MFG. CO.
500 WEST HURON STREET, CHICAGO, ILL.

Transformer Specialists Since 1895
.. ORIGINATORS OF TRU-FIDELITY AMPLIFIERS

INSULATION

HELPS

for post-war *salability*



With numerous pre-war products, processes and techniques "going by the board" when so-called non-essential production lines start rolling again, acceptance of new developments and creations will be dependent upon their capability to function satisfactorily from the customer point-of-view. Instrumental in electrical fields of endeavor, and the sustaining of the reputation for quality, will be insulation.

The diversified types of TURBO insulation—Saturated Sleeving, Varnished Tubing, Extruded Tubing, Varnished Glass Tubing, Cambrics, Composites, Mica Products, etc.—are best exemplified by their wide application in equipment in every theatre of World War II.

Electrical and mechanical advantages of TURBO are multiple, for there's a specific material to meet any of today's insulation problems—sub-zero temperatures, high heat conditions, moisture absorption, wear and abrasion, wiring perplexities, acids and alkalis, high dielectric strength, etc.

Engineers, designers and manufacturers—now engaged "in peering beyond the horizon" will find it a substantial "help" to carefully consider TURBO as a means of stepping-up product sales potentials. Write today on company letter-head for free Specimen Board; no obligation.

WILLIAM BRAND & COMPANY

276 FOURTH AVE. NEW YORK, N. Y.
325 W. HURON ST. CHICAGO, ILL.

IF IT'S

TURBO

IT SAFEGUARDS

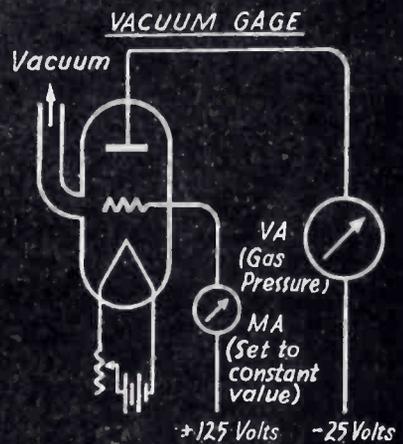
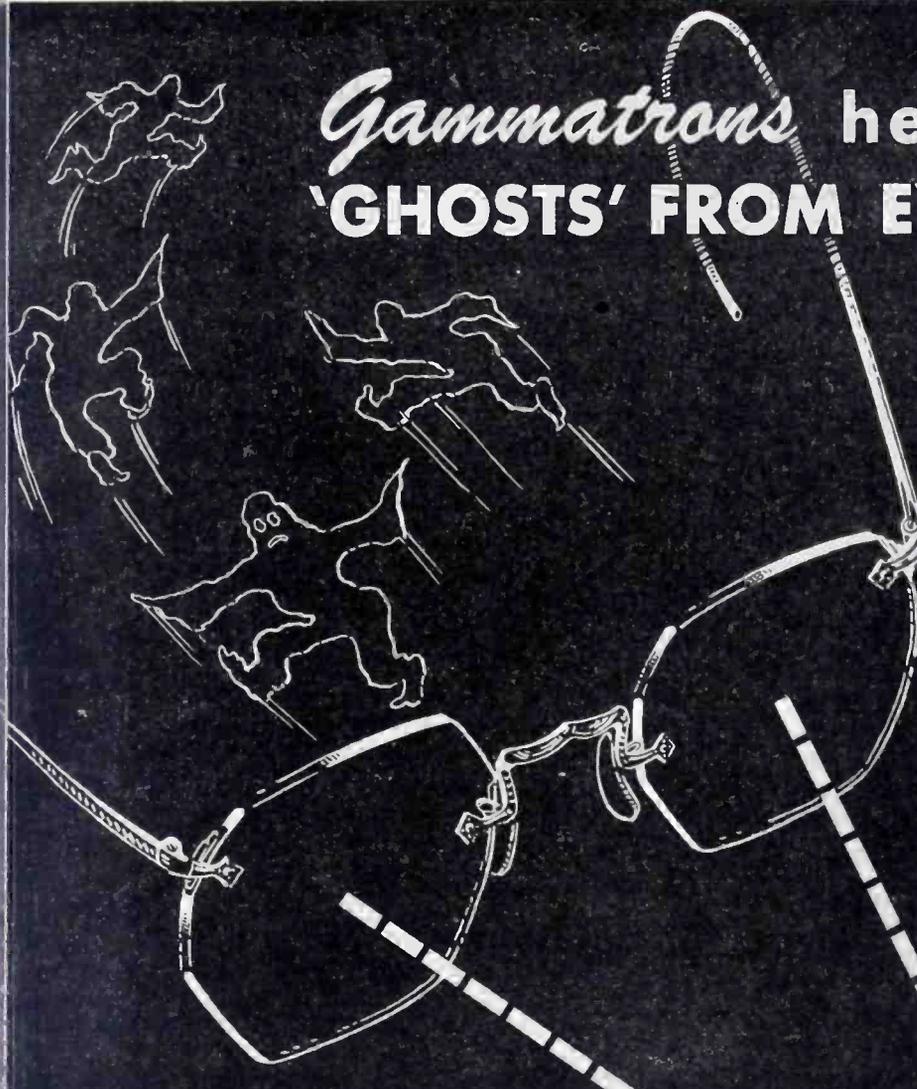
FLEXIBLE VARNISHED OIL TUBING: this TURBO insulation meets the diversity of requirements necessary to stand up against breakdowns, impairment through moisture absorption, and the general deteriorating influences caused by acids, alkalis, fumes, corrosion, etc.

VARNISHED GLASS TUBING: the extensive use of this TURBO product is directly attributable to its excellent characteristics under high heat conditions. Heavy duty operating conditions, confined areas where ventilation is minimized and other similar problems are solved.

EXTRUDED TUBING: where the effects of temperatures are apt to induce insulation embrittlement, TURBO Extruded Tubing is especially suited. Sudden climatic changes, wide fluctuations in temperature, or refrigerant operating conditions will not affect its dependability.

WIRE IDENTIFICATION MARKERS: the facilitating of production and assembling operations, with corresponding increases in functional efficiency, are effected with this TURBO insulation product. Available in any size, length or color. TURBO markers meet UL requirements.

Gammatrons help banish 'GHOSTS' FROM EYGLASSES



Circuit shows operation of the VG-54 which is essentially a triode vacuum tube. Emission current from cathode ionizes gas molecules in tube by electron bombardment. Number of ions flowing to negative electrode is a measure of gas present, and hence of vacuum pressure.

NEW GLASS COATING TECHNIQUE AIDED BY VG-54 IONIZATION GAUGES

A new technique for making glass transmit up to 50% more light through a lens system, and eliminating troublesome "ghost images", is being aided by a new Gammatron tube — the VG-54.

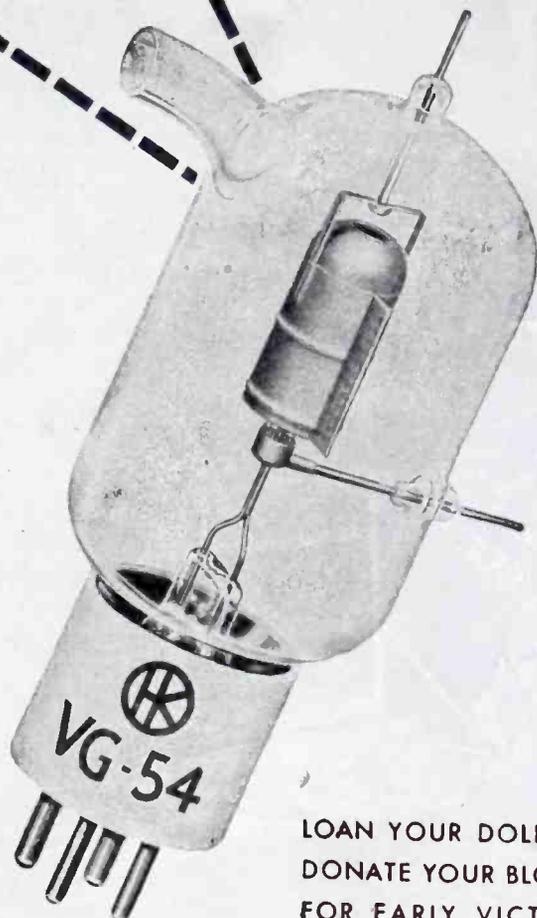
A transparent, microthin coating of magnesium fluoride is applied to the glass by a unit which produces the high vacuum necessary to vaporize this metallic salt in a few minutes, instead of the several hours previously required.

The VG-54 ionization gauge, a special type of triode which accurately measures vacuum pressure, is currently in use with units which are decreasing the surface and interior reflection of lenses and prisms in Norden bombsights.

Gammatron ionization gauges are now available for checking the operation of all types of vacuum equipment.

HEINTZ AND KAUFMAN LTD.
SOUTH SAN FRANCISCO • CALIFORNIA

 *Gammatron Tubes*



LOAN YOUR DOLLARS
DONATE YOUR BLOOD
FOR EARLY VICTORY

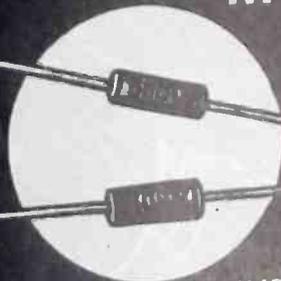
The TINYMITE

SMALLEST PAPER
CAPACITOR - - -

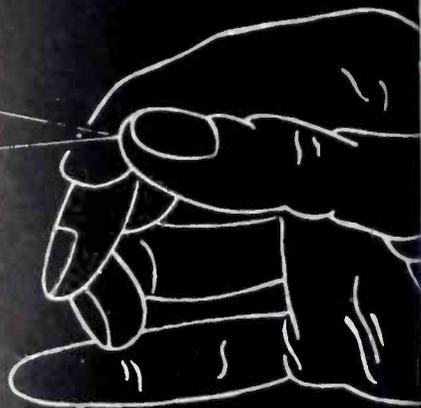
yet 100%

MOISTUREPROOF

TYPE
P5N



TYPE
P4N



FEATURES

1. Bakelite Resinoid Ends. Lead wire cannot pull out, even under hot conditions.
2. Non-Inductive.
3. Excellent Temperature Coefficient.
4. Very high leakage Resistance.
5. Fine Power-Factor.
6. Range from 20 MMFD to .25 MFD.
From 150 volts to 600 volts.
7. Types P4N, P5N for 100% humidity operation.
8. Types P4, P5 for 95% humidity operation.

Samples and price list on Request

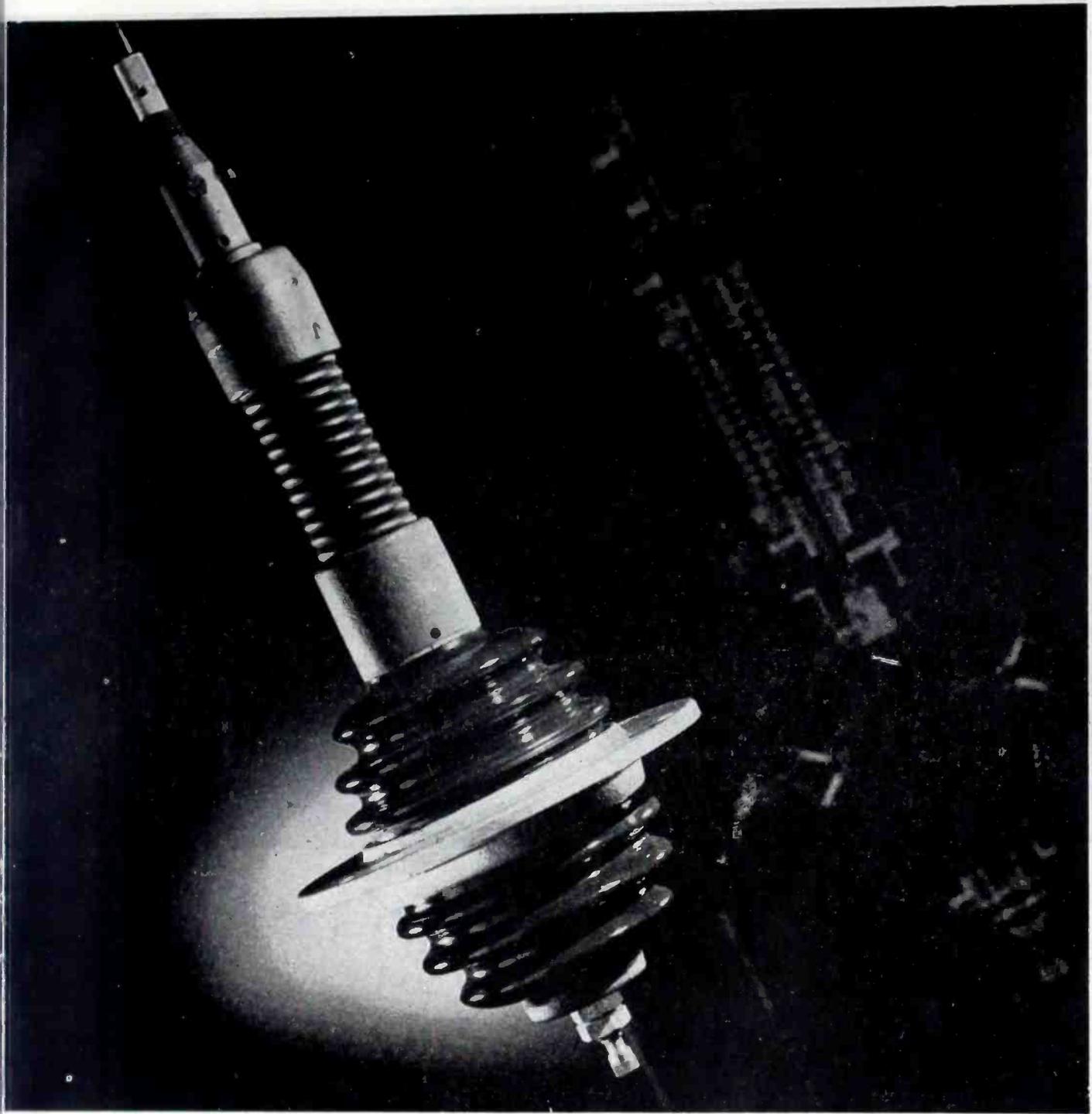
BUY EXTRA WAR BONDS . . .

Pat.
Pend.

. . . 'TIL THE WAR IS OVER.

DUMONT ELECTRIC CO.

MFR'S OF
CAPACITORS FOR EVERY REQUIREMENT
34 HUBERT STREET NEW YORK, N. Y.



LAPP-DESIGNED, LAPP-BUILT— TO DO A SPECIFIC JOB

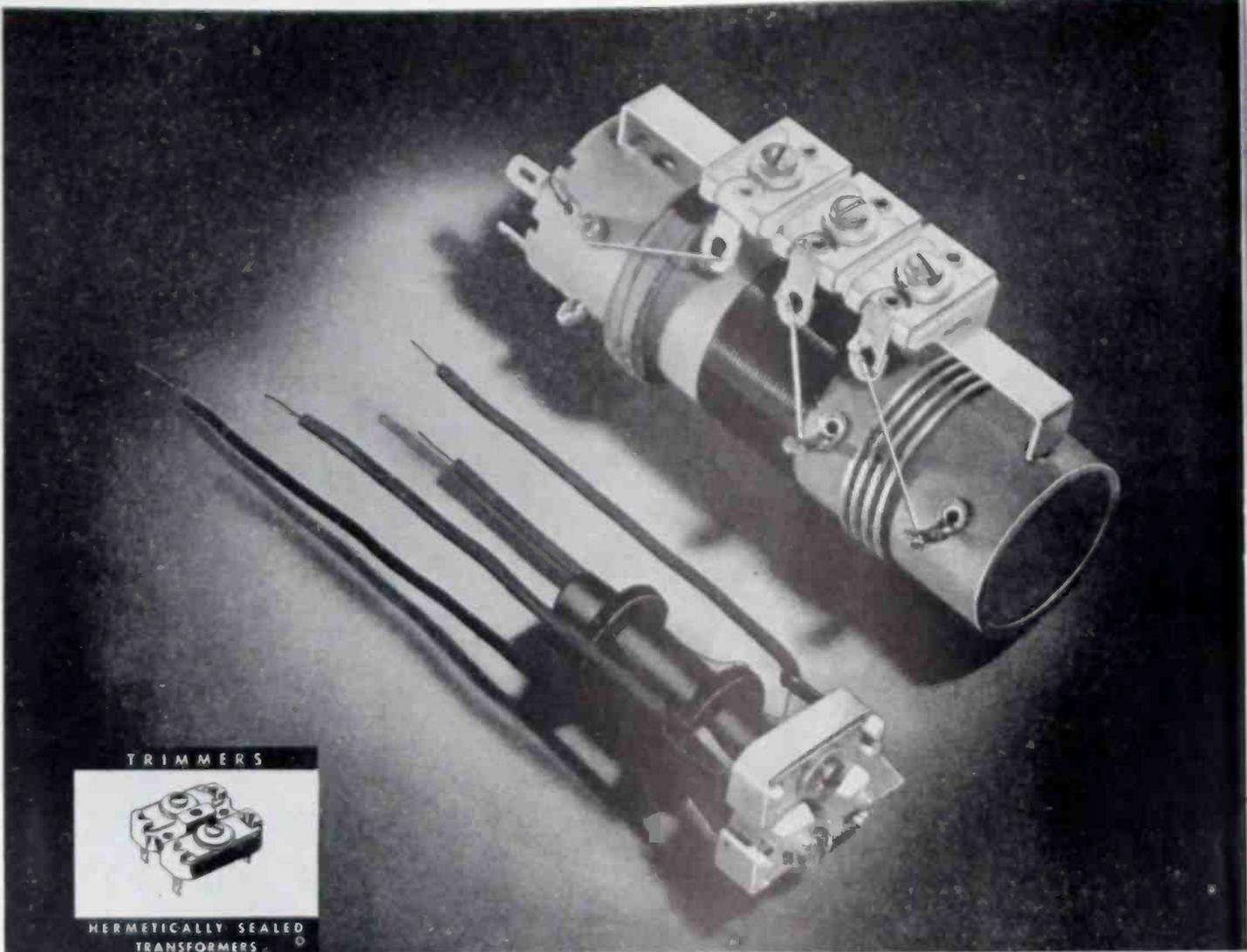
This is an antenna base insulator for use on a communications center transmitter. It is one of several Lapp designs for transmitter and receiver mast bases for military vehicular radio—on jeeps, halftracks, tanks and other rolling equipment.

Whether or not this special-purpose gadget has application to anything you build or propose to build, there's a moral in it for you. In this case, as in hundreds of others, an original and impractical design was modified by Lapp engineers—to provide a part that meets all electrical and mechanical requirements, and that Lapp can build economically and efficiently.

Lapp engineering talent and Lapp production methods are such that we can say, "If it's an assembly that can be made of porcelain or steatite and metal parts, tell us what

the requirements are and how you think it might be made; Lapp will tell you how it can best be made—and will make it." Our right to that claim has been proved over and over in military electronic production; it's going to be a competitive advantage to smart post-war electronic producers. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

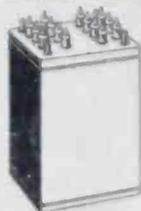




TRIMMERS



HERMETICALLY SEALED TRANSFORMERS



R. F. COILS



I. F. COILS



CHOKE COILS

INTANGIBLES

The Design of Radio Equipment has become an exact science. Yet, where tuned radio frequency circuits are concerned, many intangibles which cannot be reduced to rigid specifications can affect performance materially.

AUTOMATIC has a background of years of experience and "know how" which enable us to recognize and thereby control these possible sources of trouble.

Whether Coils or Trimmers, your requirements will be met more uniformly and reliably at no greater cost by *AUTOMATIC WINDING COMPANY* products.

AUTOMATIC
WINDING CO., INC.

KEEP BACKING
 THE ATTACK!
 BUY MORE
 WAR BONDS

COMPLETE ELECTRONIC ASSEMBLIES & COMPONENT PARTS

900 PASSAIC AVE.

EAST NEWARK, N. J.

How the HT-4 took it at 134° in the shade . . .



The following is quoted from a letter marked "Somewhere in Libya" signed by an officer in an AACS Group, USAAF:

"The writer just spent a year in Persia. Most of the time along the Persian Gulf where it really gets HOT! We operated one of your HT-4-B Transmitters near a place called Abadan. The transmitter performed very satisfactorily under the most unfavorable conditions. I doubt that your engineers ever dreamed that one of your rigs would be called upon to perform in a place where for 5 days and nights the temperature never dropped below 117 degrees and in fact it got up to 134 degrees during the daytime, that is "in the shade" temperature, the humidity was high and the air salty. Actually the transmitter got much hotter than that as it was installed in a brick building and no air conditioning, not even an exhaust fan. The HT-4-B was used on voice and gave very little trouble. One day the piece of bakelite under the phone/cw switch caught on fire but this was easily repaired. During the so called winter season, the temperature actually got as low as 36 degrees one day, we had a little trouble with mice crawling under the rig, which was set up on two 4x4 wooden sleepers. It seems the mice liked the heat and they would crawl up under the transmitter and get lodged in between the rectifier sockets and the frame when the operator switched on the transmitter the mice would fry, usually a fuse would blow but no other damage was done. We never did figure why the mice liked the Hallcrafters best. There were several other transmitters in the room but they always seemed to pick the HT-4-B; guess they were pretty smart mice!"



Just one of hundreds of real life experiences of Hallicrafters equipment. Out of this valuable experience will come your peace time short wave radio.

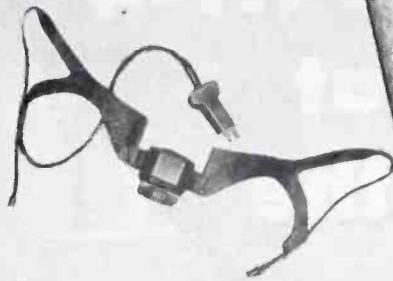
★BUY A WAR BOND TODAY!



hallicrafters RADIO

THE HALLCRAFTERS COMPANY · MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT CHICAGO 16, U. S. A.

This is the now-famous Electro-Voice "Lip Mike" which began a new era in transmission of voice and the cancellation of ambient noises.



... and this marks the second step in the development of a full line of Electro-Voice Differential (noise-cancelling) Microphones.

Electro-Voice

DIFFERENTIAL MICROPHONE

NEW MODEL 205-S

Designed, developed and built by E-V engineers and technicians

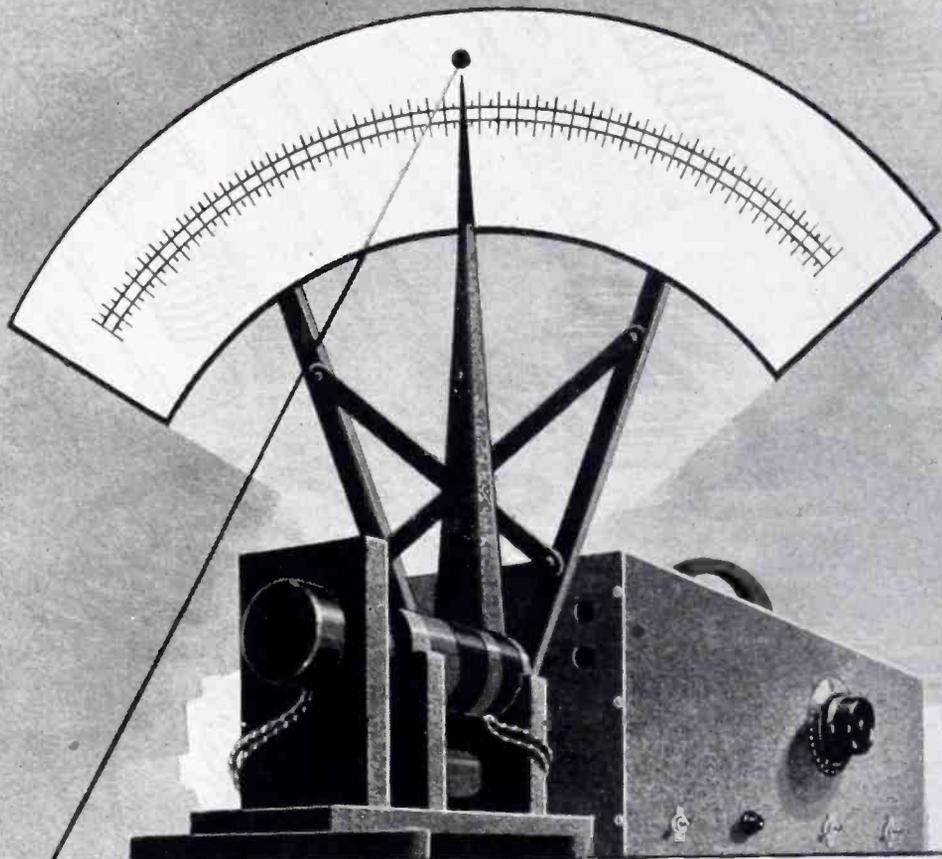
- Provides extremely high intelligibility even under intense surrounding noises
- A most efficient microphone for aircraft, factories, railroads, police and emergency services
- May be used in all temperatures from -40 to $+185$ degrees, and is interchangeable with conventional carbon microphones
- Close-talking, blast proof, waterproof and shock-resistant
- Operates satisfactorily in all positions
- Frequency response substantially flat from 100-5000 c.p.s.; high output level: -20 DB (0 DB = 1 volt/dyne/cm²); internal noise level below .001 volt.
- Press-to-talk switch opens microphone and closes relay simultaneously, if desired
- High impact phenolic case, 4" x 2-5/16"; Fiberglass wind noise filter; weighs less than 8 ounces
- Cable length, 5 ft.; panel mounting on the back; available in two models: Model 205-S, and 205-SL with switch lock.

If your present limited quantity needs can be filled by any of our Standard Model Microphones, with or without minor modifications, please contact your nearest Electro-Voice distributor.



Electro-Voice MICROPHONES

ELECTRO-VOICE CORPORATION • 1239 SOUTH BEND AVENUE • SOUTH BEND 24, INDIANA
Export Division: 13 East 40th Street, New York 16, N. Y., U. S. A. Cables: Arlab



measuring mighty muscles of midget motors

● The might of this midget motor is no secret to this special dynamometer used in the Utah laboratory. It accurately measures the horsepower; actually pre-determines the successful performance of this Utah motor in its many vital functions in actual use.

Utah's complete testing service is

playing an important part in the war effort today, and is scheduled for an equally important role tomorrow . . . in adapting war-born electronic and radio developments to commercial and consumer needs. ★ ★ ★

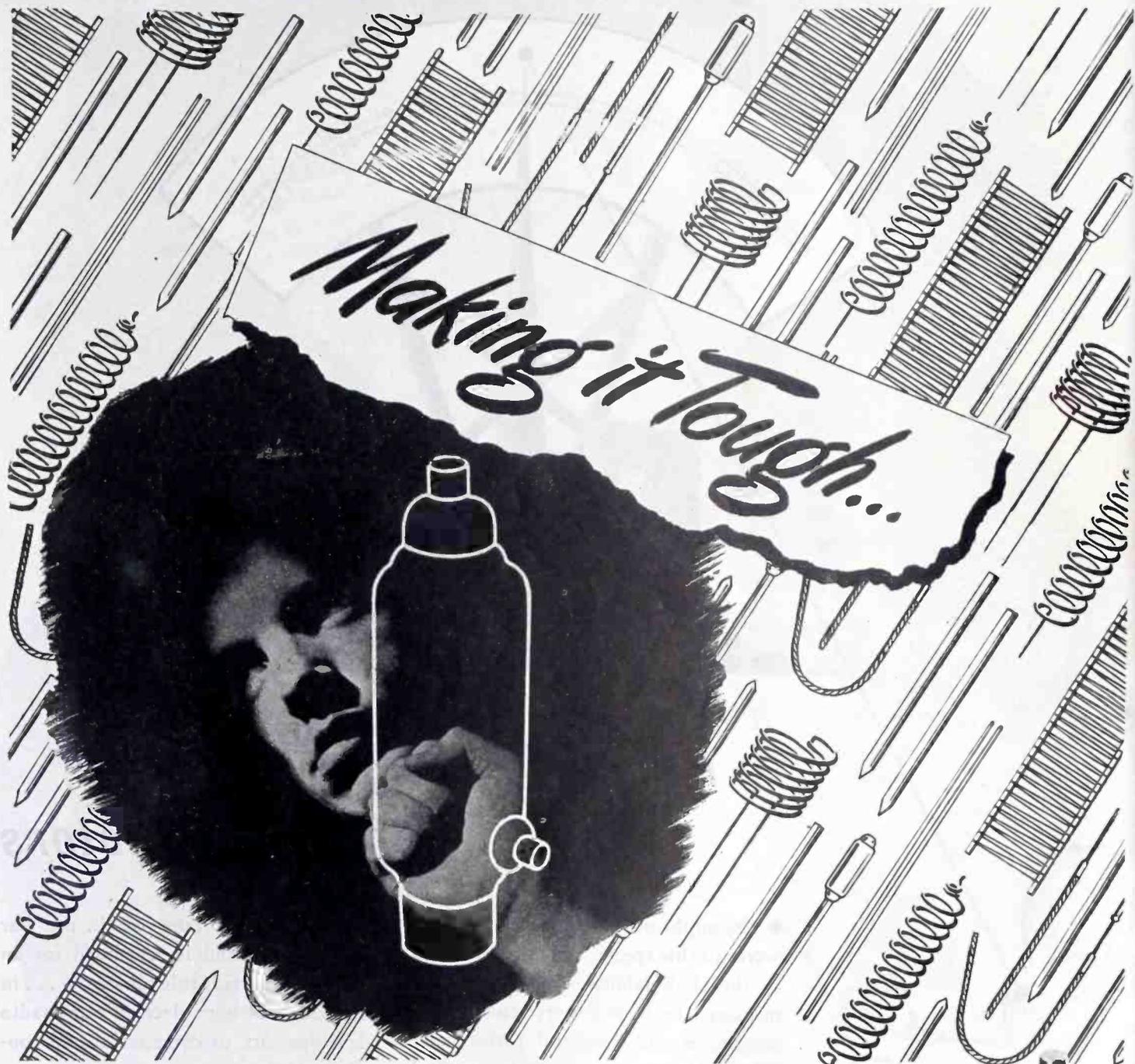
Every Product Made for the Trade, by Utah, Is Thoroughly Tested and Approved

Keyed to "tomorrow's" demands: Utah transformers, speakers, vibrators, vitreous enamel resistors, wirewound controls, plugs, jacks, switches and small electric motors.



Utah Radio Products Company, 857 Orleans Street, Chicago 10, Ill.

utah



... for callite tube components

Heavy duty oscillator tubes for high frequency heating are specially designed to withstand widely varying conditions of load and frequency. The United Electronics Company of Newark, N. J., one of the leading producers of such tubes, has long relied on Callite for high quality components — especially tungsten kulgrid welds, a Callite development.

An important requirement in the manufacture of vacuum tubes has been a stranded wire which does not oxidize readily at the high temperatures required in the successful steps of pro-

duction such as beading, stem-making, sealing-in and exhaust. Kulgrid has the necessary high-heat and electrical conductivity for efficient operation when used in conjunction with Callite tungsten in the manufacture of hard glass electronic tubes. Callite Tungsten Corporation, 544 39th St., Union City, N. J. Branch Offices: Chicago and Cleveland.

United Electronics Tube
KU-23 for r. f. heating,
contains Callite tung-
sten kulgrid welds.

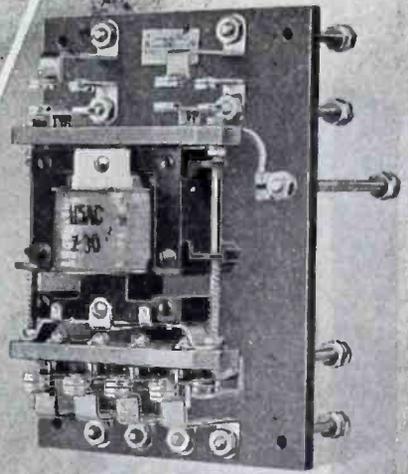
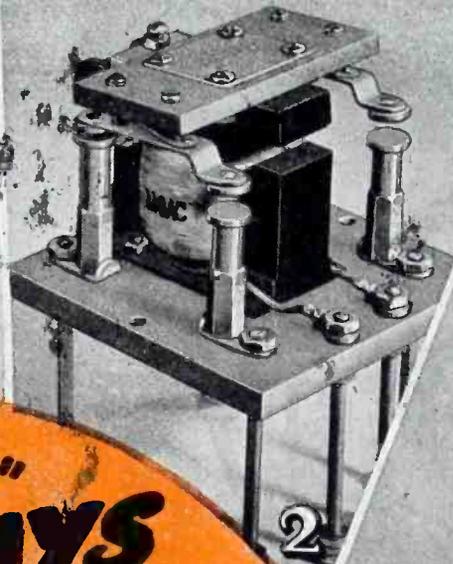
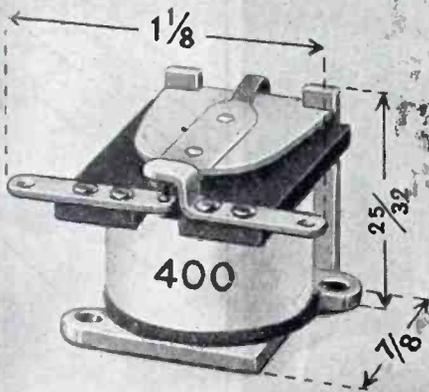


**R FOR R⁺ DAY
RECONVERSION**

Discuss your post-war plans with our engineers. Our accumulated knowledge and experience is worth having — Now. We can help you on the design and selection of materials.



Callite tube components



"HUSKY" 5 RELAYS

you will welcome for
POST WAR PROJECTS

This midget feather-weight type 400 Relay is designed for portable battery equipment where coil wattage, weight and size are highly important. It weighs only 25 grams. The magnetic circuit is highly efficient. Contact Arm and Armature Spring are one continuous piece with NO coil springs or pigtails. Palladium Contact is rated at 250 milliamperes.

This powerful A.C. Hinge Type Relay is designed for radio transmitting and receiving apparatus. The special hinge and spring arrangement prevents vibration and eliminates A.C. Chatter and Hum. Relays are designed for panel mounting and furnished with studs to any length desired.

This Solenoid A.C. Plunger Type Relay is especially suited for radio transmitters and other sensitive communications equipment. The A.C. Solenoid is powerful and efficient. The fact that pole faces are accurately ground after the laminations are assembled and riveted, results in elimination of A.C. Chatter and Hum. Studs of any length desired for panel mounting.

For general purpose circuit control our Type 17 Series of Relays are very popular. Quite frequently this series provides for all the relay requirements in a given design, simplifying the wiring and mounting. The 1/4" diameter fine silver contacts are rated at 10 amperes.

★★★**RO-TROL** introduces a new basic principle of Relay operation especially designed to withstand severe vibration, temperature and humidity specifications. It is a compact two position driving mechanism providing up to 30 degrees clockwise or counter clockwise rotation from the normal position. When used to operate switch wafers it provides a great variety of contact arrangements. Designed to meet severe military conditions "RO-TROL"—presents great advantages for many post-war applications.

← **Get Catalog E-10**

These 5 practical Relays, and many others, are illustrated and fully described in our RELAY CATALOG. Write today for your copy.



30 Years
Experience

PRICE Brothers Co. FREDERICK, MARYLAND
RELAYS, CONTROLS, AND MAGNETIC DEVICES FOR ELECTRONIC & INDUSTRIAL APPLICATION





the Improvement goes on.

ENDLESSLY

FORMICA



● Since 1913, in the Formica Laboratories, a considerable force of competent research men has been busy every day seeking new ways to improve Formica and its usefulness to industry.

They have worked out a long line of improvements which have been additions to the art. During these years they have been exceptionally busy, and producing

Among the important recent developments have been glass cloth and glass mat grades for high mechanical strength, and improved insulation of high frequency currents; Pregwood for airplane propeller blades and other mechanical uses; alkali resistant grades for chemical processes; better laminated translucent sheet, sturdy and more decorative Formica finishes.

There are others which will soon be unveiled. The knowledge of this laboratory is at your disposal when you have a problem in the use of laminated plastics to solve. Ask for it.

"The Formica Story" is a moving picture in color showing the qualities of Formica, how it is made, how it is used. Available for meetings of business groups.

THE FORMICA INSULATION COMPANY, 4661 Spring Grove Avenue, Cincinnati 32, Ohio

making mountains
out of molehills



Dependability is a lot of little things that add up—it's the end result of paying due homage to all the molehills of production so that the finished product will give a mountain of service. Like paying strict attention to seemingly unimportant details of workmanship. Like emphasizing the work of skilled technicians who are experts in their special field of building finer capacitors.

That's the way we've been making capacitors since 1910. Many of our men and women have been working on C-D capacitors for nearly 34 years. Others have been with us for five—ten—twenty years of loyal, devoted service.

Dependability is a C-D tradition. Every C-D capacitor has built into it the dependability . . . the skill, experience and research . . . that belong only to the leader, Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey.

TYPE YAT—A compact, low capacity Dykanol "G" bypass capacitor—hermetically sealed in specially-treated drawn metal container. Range at 600V.—.05 mfd. to 1 mfd. at 100V.—.05 mfd. to .5 mfd.



CORNELL-DUBILIER CAPACITORS



MICA • DYKANOL • PAPER • WET AND DRY ELECTROLYTICS

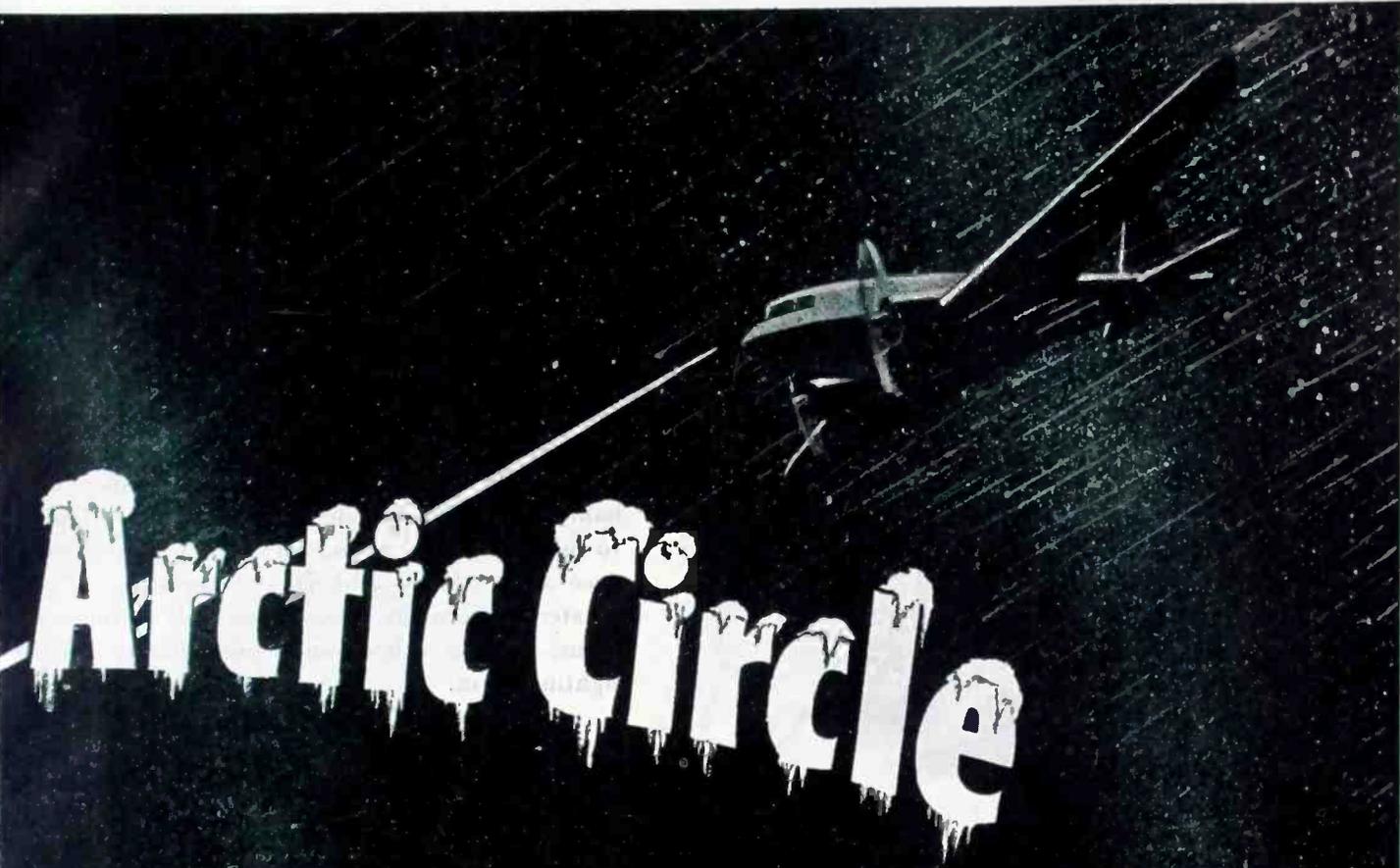
ALSO AT NEW BEDFORD, BROOKLINE, WORCESTER, MASS.; PROVIDENCE, R. I.

Federal

Low Frequency Transmitters Used

inside the





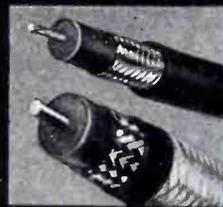
Arctic Circle

To maintain unflinching communication between airports and from field to plane inside the Arctic Circle, requires the use of low frequency transmitters that will operate reliably far from service facilities.

Federal, pioneer in both low and high frequency radio communication, provides the solution with its 10 KW low frequency transmitter, consisting of an exciter, rectifier, RF transmitter and antenna tuning equipment, housed as separate units. Compact, light in weight, they may be transported in a cargo plane without dismantling.

Through blinding storms and almost perpetual night, pilots in the Far North stake their lives on the dependability of these Federal radio transmitters.

Your transmitting equipment may never be called upon to meet such rigorous demands. But, whatever your requirements are in low or high frequency transmission, Federal, with its technical experience and leadership in radio communication, is prepared to solve your problem.



Intelin High Frequency Power and Coaxial Cables manufactured by Federal, meet every construction and performance requirement of the most exacting specifications.

Federal Telephone and Radio Corporation

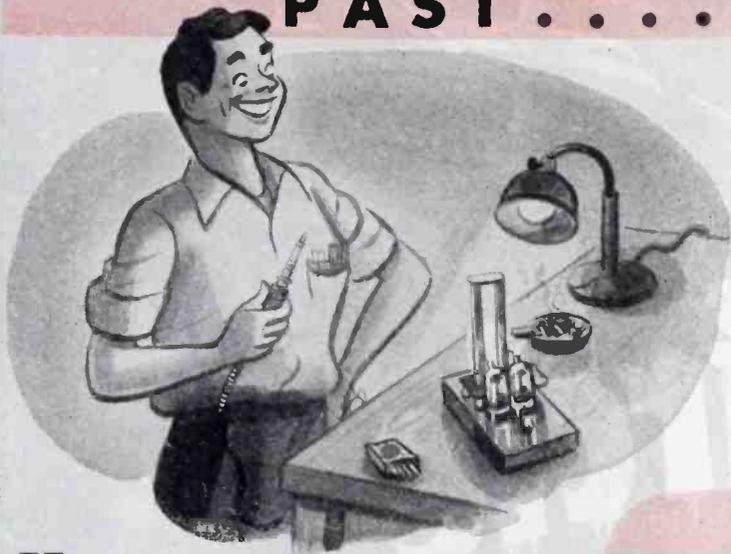
Newark 1, N. J.



"Ham" Radio and

HYTRON

PAST



THE radio amateur trained himself during peace to be invaluable to the Nation during war. Specializing on tubes exclusively designed for ham radio, Hytron when war began was prepared for immediate and direct conversion to war production. Hytron transmitting and special purpose tubes proved by the ham were ideally suited—with little or no changes—to military applications. Years of practical experience made Army and Navy specialists of radio amateurs overnight. Peacetime tools of these same hams, Hytron tubes joined immediately this new fighting team.

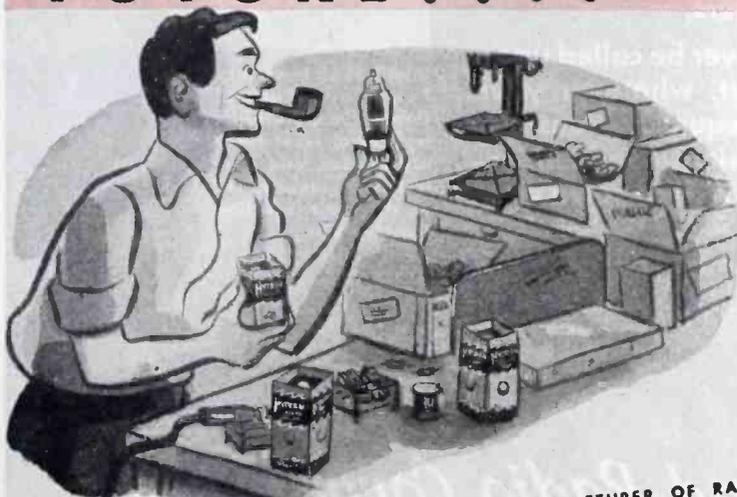
HAMS with the Services in all parts of the world know the war job Hytron is doing. High-speed receiving tube techniques plus know-how derived from special purpose engineering of tubes for the amateur, make possible a flood of dependable Hytron radar and radio tubes to these fighting ex-hams and potential hams. Proud of winning the Army-Navy "E" for its performance on a huge production job, Hytron is also proud of its ham friends who are transforming innocent-appearing Hytron tubes into deadly weapons.

. . . . PRESENT



THERE should be no concern about adequate post-war amateur frequencies. Excellent wartime performance on far-flung battle fronts has made for ham radio many enthusiastic and influential friends. The ARRL reports that it looks forward with absolute confidence to the opening of new frontiers in expanded frequency ranges to be made available to the post-war amateur. Hosts of hams will return to their old friend, Hytron. For the more familiar lower frequency bands—the very high frequencies—or the new superhighs—their choice will be Hytron.

FUTURE



OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION

ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.



BUY ANOTHER WAR BOND

RADIO SPEAKERS

And Transformers

Consolidated Radio Products Co. has complete modern production and engineering facilities to supply the finest radio speakers available. Speakers can be furnished in the following ranges:

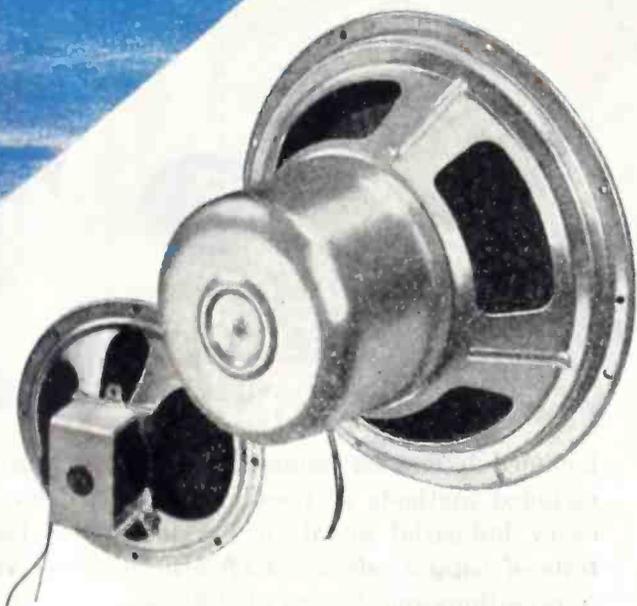
Dynamic Speakers from 2 inches to 18 inches

Permanent Magnet Speakers from 2 inches to 18 inches

Headsets

Consolidated Radio is also a nationally known manufacturer of small and medium transformers including Pulse Transformers, Solenoids and Search Coils.

Engineering service is available to design transformers and speakers for special applications, or to your specifications.

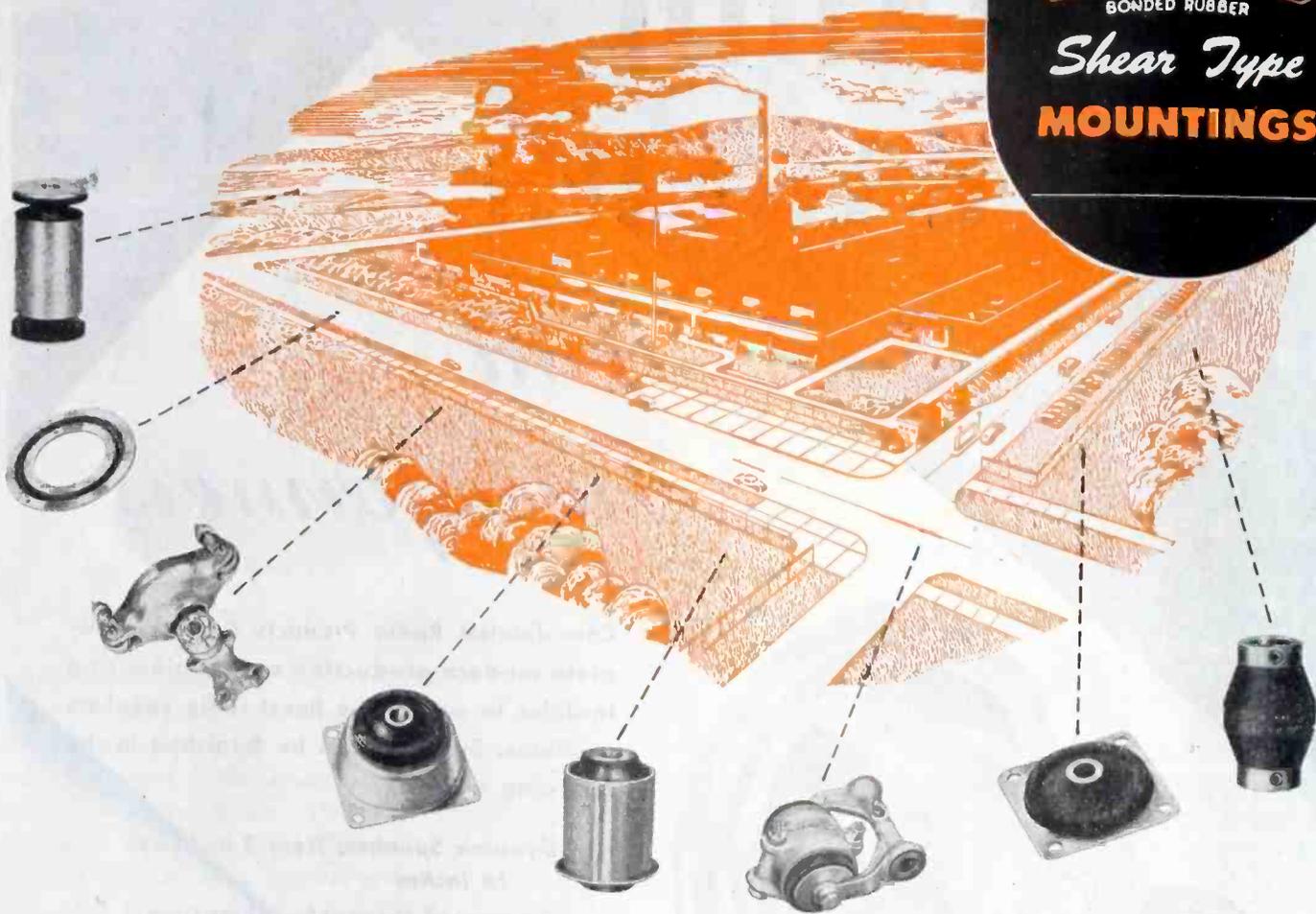


Electronic and Magnetic Devices
CONSOLIDATED RADIO

Products Company
350 W. ERIE ST., CHICAGO 10, ILL.



The Plant Behind The Product . . .



AN idea that was born over twenty years ago; an idea that was painstakingly developed on reams of paper covered with engineering formulas, drawings and mathematical computations; an idea that was proven in countless laboratory tests. That idea accounts for the fact that Lord has had to make three additions in as many years, to take care of the war-time demand for the best in vibration control mountings for airplanes, ships, tanks, and a hundred other tools of war.

The idea was that a Shear Type Mounting, properly designed, is vastly superior in vibration control to compression or tension type mountings. The work on paper and in the laboratory has continued; it has

included designs for thousands of different jobs; it has included methods of bonding rubber to practical every industrial metal; it has included exhaustive tests of *natural rubber and synthetic rubber* of varying compositions and degrees of stiffness.

It has all resulted in Lord being the authority on vibration control and isolation. When a tough vibration problem comes up, the typical expression heard from the designer, the engineer, the shop superintendent is, "Send it to Lord".

Because Lord knows, there is a solution to your vibration problem. Perhaps it's in our free literature perhaps you would do well to call in a Lord Vibration Engineer. No obligation attached to either service.

IT TAKES RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

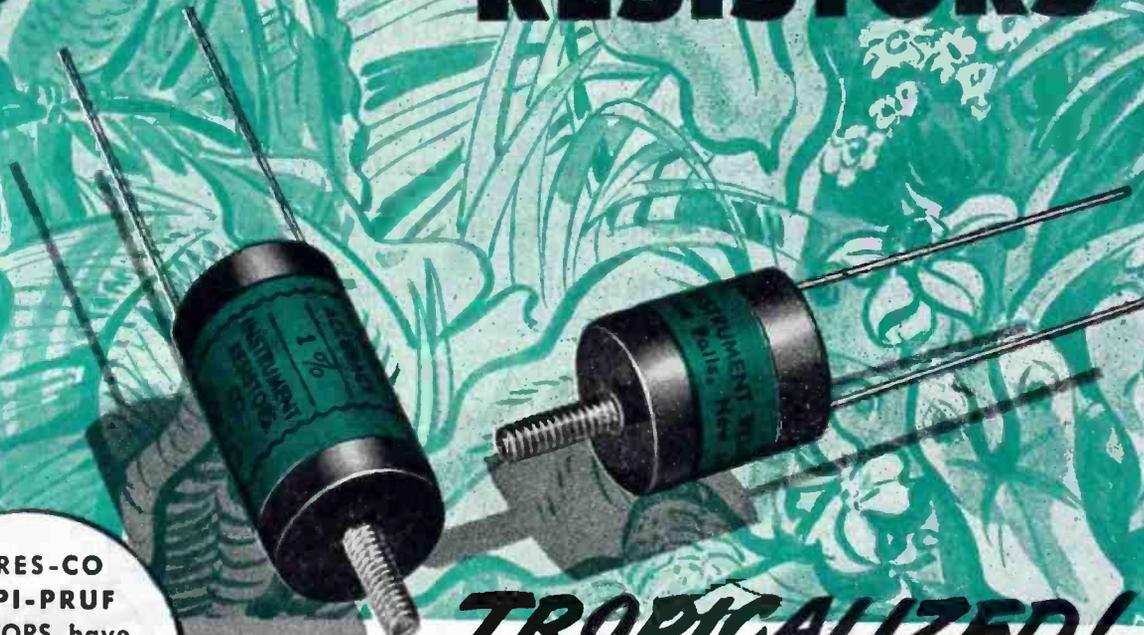
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Originators of Shear Type Bonded Rubber Mountings

**Do More Than Before—
Buy EXTRA War Bonds**

NOW! IN-RES-CO

TROPI-PRUF RESISTORS



TROPICALIZED!

**IN-RES-CO
TROPI-PRUF
RESISTORS** have
all these features



1. Specially-engineered cap design for tight, penetration-proof fit.
2. Terminal leads bonded to cap for hermetic seal.
3. Special IN-RES-CO banding material for lasting protection.
4. Special IN-RES-CO fungus-proof coating.
5. One-piece molded bakelite shell, with cap, assuring rugged durability and dependability.
6. #6-32 mounting screw, an integral permanent part of the shell.

A new conception of resistor performance



Present day application of electrical equipment under drastic climatic variations, demands new considerations and requisites in engineering. In tropical climates, absorption and adsorption of humid spore-bearing atmosphere is not uncommon, and subsequent fungus growth plays havoc with delicate components and adjustments. Product failure—complete and irreparable in a matter of only two days—is the usual result. Thus, fungicidal protection becomes a foregone conclusion.

IN-RES-CO engineers—responsive to the new requirements, offer the complete TROPI-PRUF line of tropicalized resistors. New, proved and accepted, each wire-wound unit—itsself carefully protected against corrosion, moisture and deteriorating influences—is permanently sealed in a hermetically-tight bakelite case. Terminal leads are brought through close-tolerance openings,

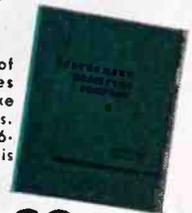
and sealed to prevent creepage of moisture or fungus growth.

After dehydration, the complete piece receives several carefully controlled coatings of fungicidal finish. Signal Corps #71-2202-A approved, this protective film is non-toxic, resistant to thermal shock, mold and mildew, and possesses high dielectric strength. It is designed to withstand Navy Salt Spray tests, electrolytic action, condensation and corrosive influences.

All IN-RES-CO wire-wound resistor units are available in TROPI-PRUF. Included are a wide diversity of components for both general and high accuracy applications.

WRITE FOR CATALOG.

The complete IN-RES-CO line of high-accuracy units, includes meter multipliers, shunts, choke coils, solenoids and special coils. Write for your copy of this 16-page data compilation; there is no obligation.



INSTRUMENT RESISTORS CO.

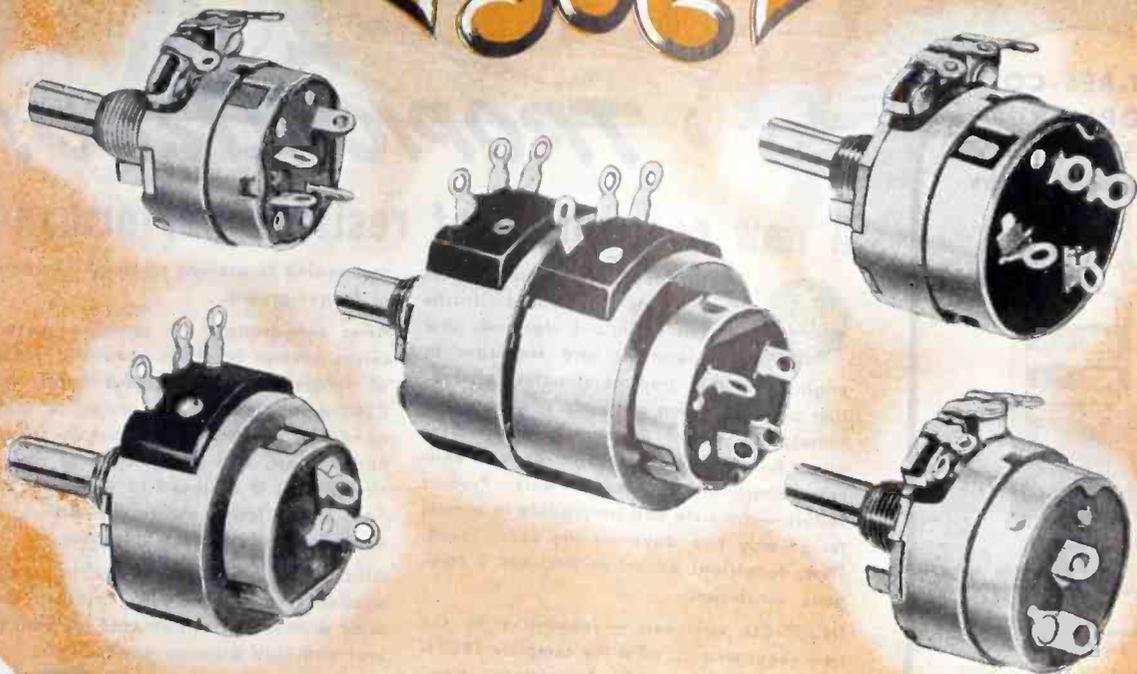
25 AMITY STREET, LITTLE FALLS, NEW JERSEY



CHICAGO TELEPHONE SUPPLY *Company*

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Specialists in the technical research, skilled engineering and precision mass production of variable resistors, both wire wound and carbon types, Chicago Telephone Supply Company is a name synonymous with quality products and unexcelled service.



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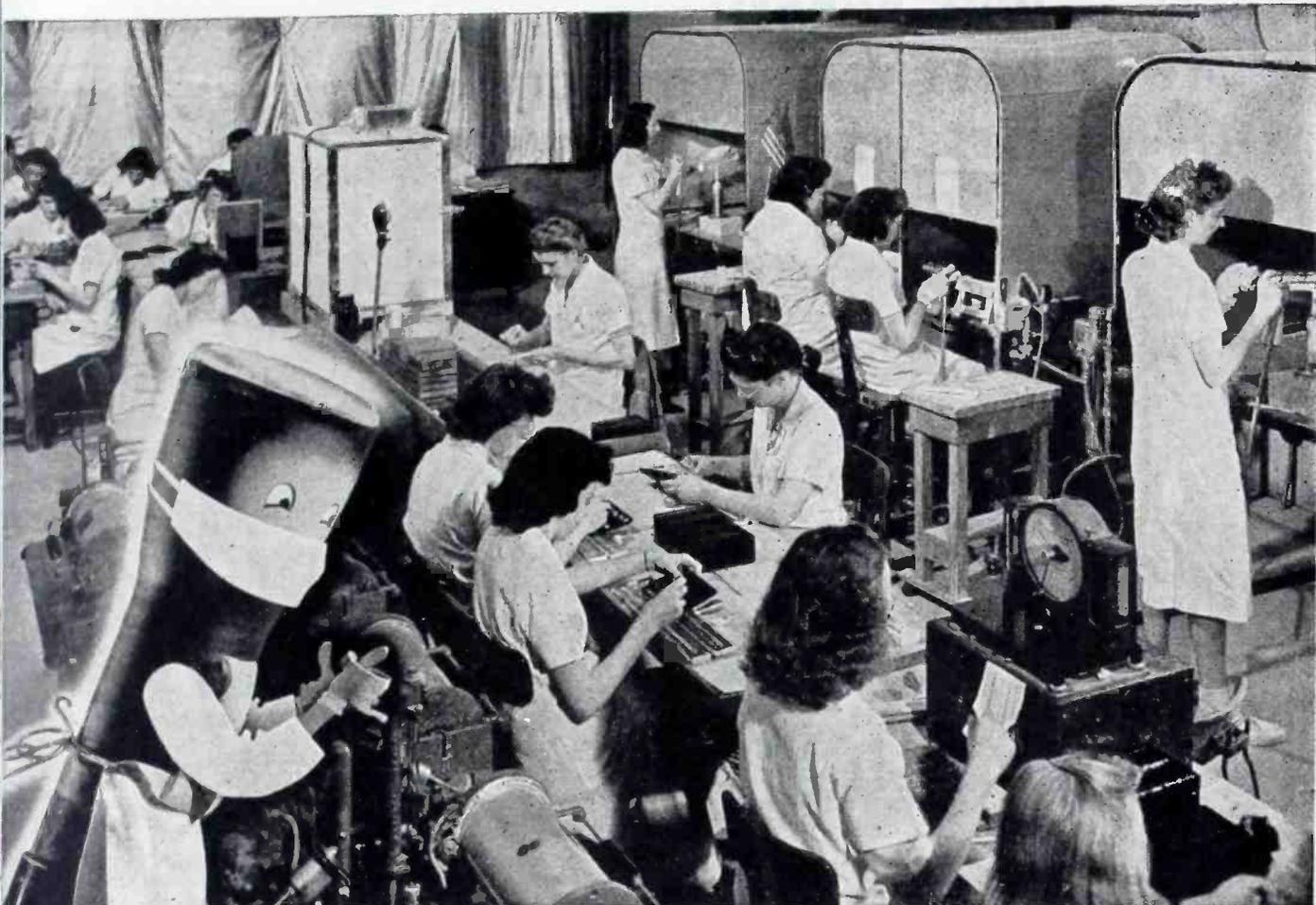
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IN CANADA
C. C. Meredith & Co.
Streetsville, Ontario

Manufacturers of Quality Electro Mechanical Components Since 1896



NO SWEATER GIRLS, Please

Electronic tubes are as sensitive to lint, dust and minute particles of foreign matter, as a hay fever sufferer is to pollen. Unless the most stringent precautions are taken to keep tube parts free from impurities, trouble is sure to follow. Trouble—such as noisy receivers . . . discoloration or spots on the screen in cathode-ray tubes . . . power failure in transmitting tubes.

That is why National Union engineers go the limit to assure absolute cleanliness all along the production line. As an example, the model N. U. cathode spray room, pictured above, is not only clean—it's *hospital clean*. No fuzzy

sweaters or lint-shedding dresses are worn here. There is no dust, no dirt, because it's air-conditioned. Humidity and temperature are precisely controlled. The whole room is washed from ceiling to floor once a week. Then, to make sure, the individual parts are sterilized—some in boiling water—others in special solvents—still others by hydrogen firing.

Even should other factors be equal, the cleaner tube is the better tube. Remember this—and *count on National Union*.

NATIONAL UNION RADIO CORPORATION, NEWARK, N. J.
 Factories: Newark and Maplewood, N. J.; Lansdale and Robeson, Pa.

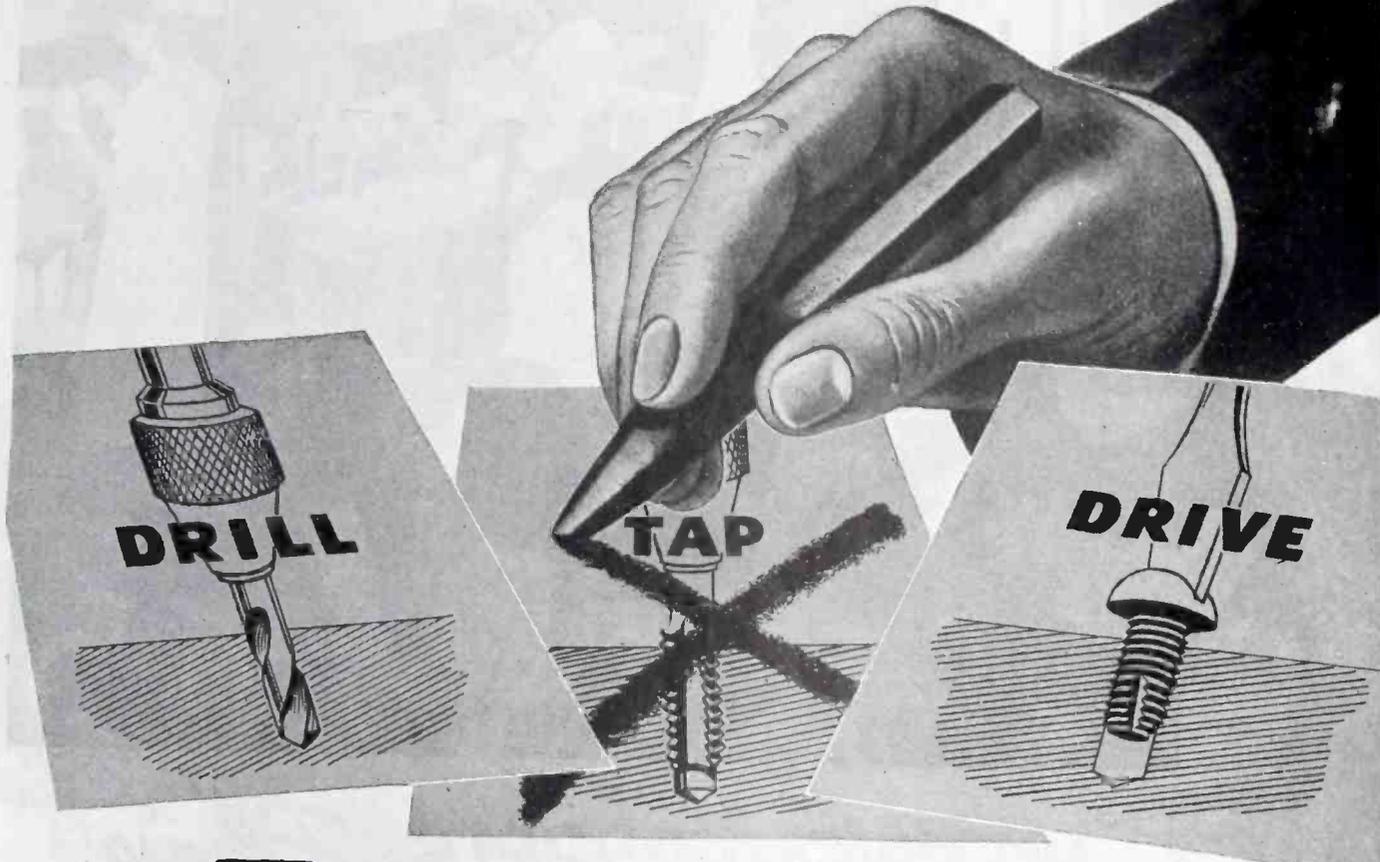


NATIONAL UNION

RADIO AND ELECTRONIC TUBES

Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs

**WHY BURDEN
YOUR POST-WAR PRODUCT
WITH NEEDLESS TAPPING COSTS!**

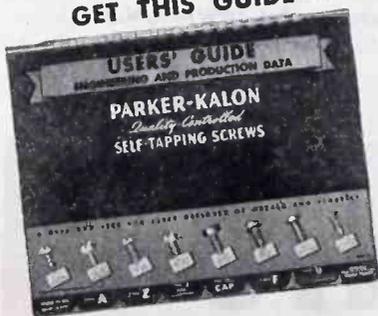


... USE *The Short-Cut Method!*

Let the P-K Assembly Engineer show you how to take out tapping and put in PROFITS. The Short-cut fastening method, with Parker-Kalon Self-tapping Screws, eliminates the tapping and tap expense of machine screw fastenings. On many jobs, this means savings in assembly time and labor of from 30% to 50%.

You can make similar savings when you use P-K Screws to replace slow bolt-and-nut fastenings, troublesome inserts in plastics, riveting in hard-to-reach places.

GET THIS GUIDE —



TO HELP YOU PLAN POST-WAR ASSEMBLIES, Parker-Kalon has prepared a handy "Users' Guide", giving information you need on all types of P-K Self-tapping Screws. It is arranged so you can find facts quickly, and made file size, with a hanger for use as a wall chart. Write for your copy. Parker-Kalon Corp., 208 Varick St., New York 14, N. Y.

One operation makes a fastening with a P-K Screw. You just drive it into a plain, untapped hole. Truly a short-cut method! It makes a stronger fastening, too.

Before your post-war assembly practices are set, talk over your fastening problems with a P-K Assembly Engineer. You'll find his recommendations unbiased. He'll suggest P-K Screws only when they will save time, lower costs, provide stronger fastenings. No matter what kind of material you are working with—light or heavy steel, cast iron, aluminum, brass, or plastics—you'll find you can adopt P-K Screws to advantage in 7 out of 10 cases.

No special tools or skilled help are required. You can switch to P-K Screws overnight.



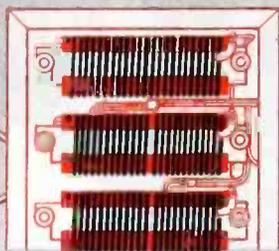
SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

PARKER-KALON
Quality-Controlled
SELF-TAPPING SCREWS

Another Famous D-H Alloy Advance

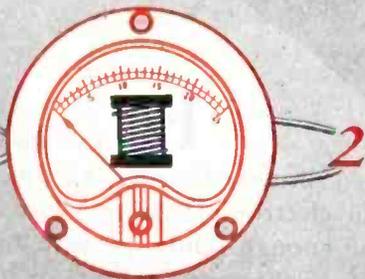


... does **3** JOBS EFFICIENTLY

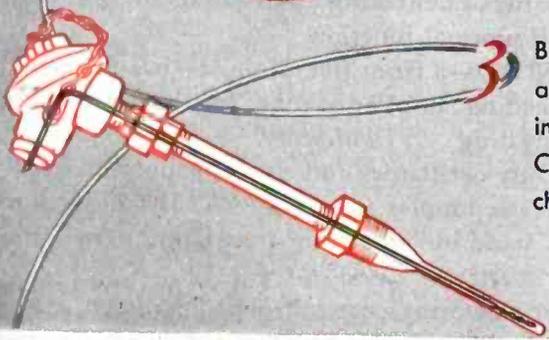


Advance* is a Driver-Harris alloy made from electrolytic Nickel and Copper under close control of exclusive Driver-Harris methods. It possesses a number of remarkable properties ideally suited for these 3 distinctly different applications.

1 High electrical resistance (294 ohms per Circular Mil-foot), great ductility and non-corroding properties make it particularly good for winding heavy duty industrial resistors employed in motor starting and controlling equipment. Both wire and ribbon are used in this application.



2 In finer sizes negligible temperature co-efficient of resistance ($\pm .00002$) combined with high resistivity makes it the most desired resistance alloy for winding precision resistors of the type used in electric meters and laboratory testing devices.



3 Because Advance* develops high and uniform thermal e m f against Platinum, Copper or Iron, it is used extensively by all instrument manufacturers in the well-known Iron-Advance and Copper-Advance (Constantan) Thermocouples. Small temperature changes are clearly indicated through larger scale deflections.

*Trade Mark Reg. U. S. Pat. Off.

Advance* is only one of a large, famous family of versatile Driver-Harris resistance alloys that can be relied upon to make your post-war products more dependable. For important information about improved resistance alloys write for a free copy of Data Book R-42 . . . a complete text on Advance and other D-H alloys.



Driver-Harris COMPANY

HARRISON, NEW JERSEY

BRANCHES: CHICAGO • DETROIT • CLEVELAND
LOS ANGELES • SAN FRANCISCO • SEATTLE

Special Purpose Alloys Since 1899



TUBES BY UNITED



FOR the widely varying conditions of load and frequency encountered in electronic heating "just any tube" is good enough. Only specially designed tubes are capable of delivering a full life of efficient operation for this unusual function.

UNITED—a front line pioneer—has for many years been the leading supplier of tubes for the most widespread field of R-F heating . . . Diathermy.

Heavy Duty oscillators and power supply mercury rectifiers by UNITED are popular among users of H-F induction heating because they "stand up" under the fluctuating demands of this application.

To lower your operating costs, through increased life expectancy of your tubes, equip with the UNITED tubes, ideally designed for H-F heating . . . Write for technical data and tube interchange information.

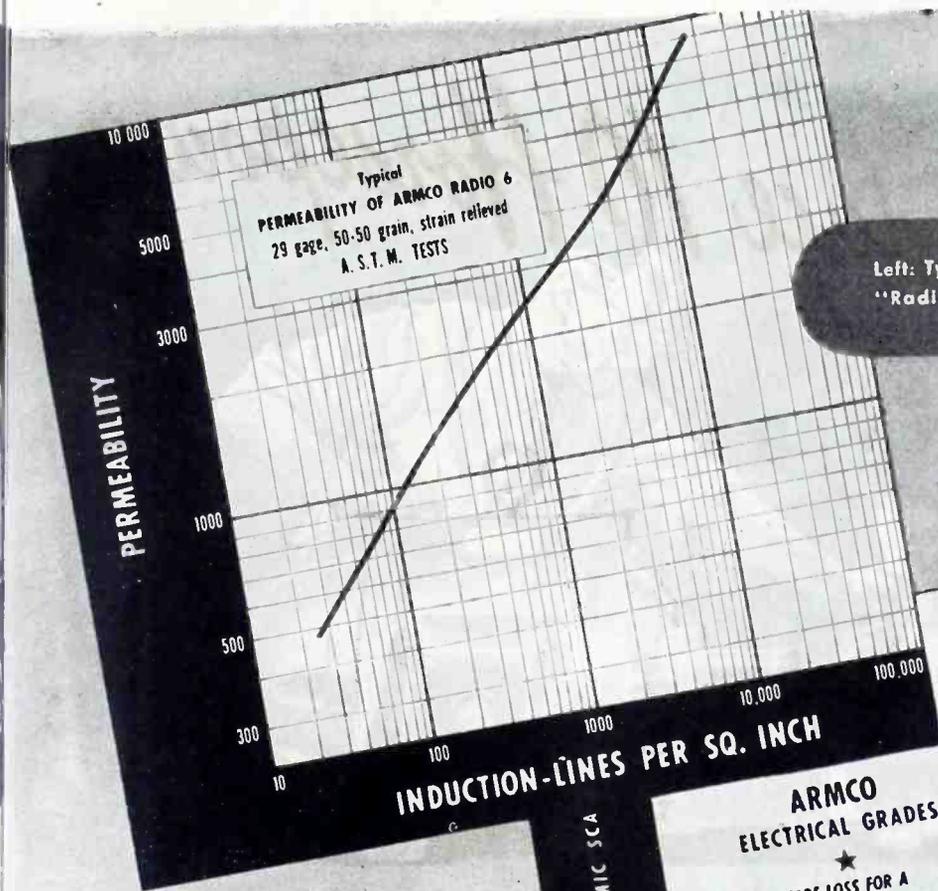
UNITED ELECTRONICS COMPANY

NEWARK 2



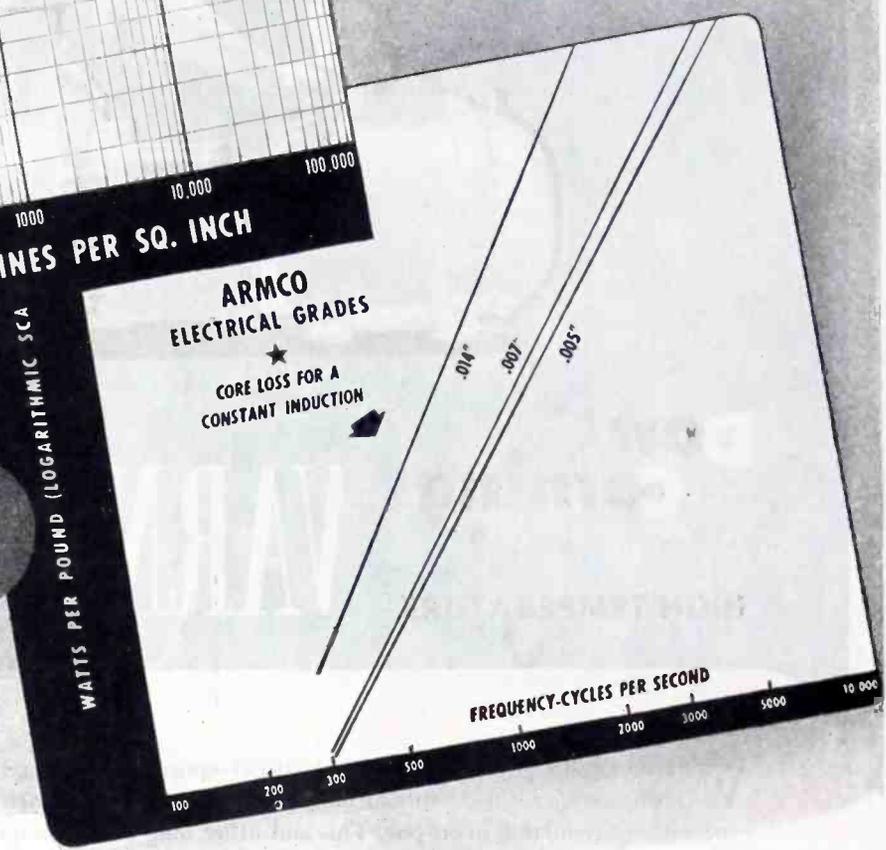
NEW JERSEY

TRANSMITTING TUBES EXCLUSIVELY SINCE 1934



Left: Typical high permeability of ARMCO "Radio 6" is shown on this chart.

Right: This curve shows the core loss relationship of light-gage ARMCO Electrical Steel for varying frequencies at a fixed induction.



War-Tests mean much to your peacetime products

Many kinds of electrical sheet steel products for home and industry will benefit greatly from lessons learned during the war. Electrical steels with improved properties will help bring about important new peacetime applications.

The communications field is one example. The exacting demands of war for up-to-the-minute communications systems and accurate firing controls will lead to *life-saving* devices when peace comes. Our transportation systems will be safer and run right on schedule, our communications faster and more accurate because of these remarkable developments in the science of electronics.

Special ARMCO High Silicon Steels are being used in much of this high frequency equipment. Other grades of ARMCO Electrical Sheets are undergoing the severe tests of war too. Motors, transformers and generators will be more efficient and durable be-

cause of exacting wartime requirements.

Remember these improved electrical sheets and coils when you design post-war products. You'll find a correct Armco grade for every need. And you'll get steel that is flat, clean-surfaced and ductile, steel of top magnetic properties with low core loss and exceptional permeability. For detailed information just address The American Rolling Mill Company, 2731 Curtis St., Middletown, Ohio.

EXPORT: THE ARMCO INTERNATIONAL CORPORATION



THE AMERICAN ROLLING MILL COMPANY

Both Produce 10 Horsepower



**Dow
Corning**

VARNISH

HIGH TEMPERATURE

MAKES THE DIFFERENCE!

WHEREVER design limitations of electrical equipment are based on insulating temperature, you can now reduce weight by as much as 50 per cent without reduction in output. This and other long desired improvements are accomplished by utilizing the recently developed Dow Corning Silicone Varnishes. These totally new products make possible high temperature insulation of such remarkable thermal endurance that, in addition to weight reduction, the following advantages are attained:

- Increased operating temperatures
- Increased life under severe service conditions
- Increased output

Motors of present design for use under severe service conditions of temperature and humidity may also take advantage of Dow Corning High Temperature Varnish. Dow Corning Silicone Varnished Fiberglas magnet wire, Fiberglas tapes and sleeveings, and Fiberglas cloth, alone or laminated with mica, are available for use in this type of construction. We invite consultation.

**Dow Corning Silicone
Products Include:**

Fluids—Inert liquids, with viscosity little affected by temperature changes; for operation at sub-zero as well as elevated temperatures.

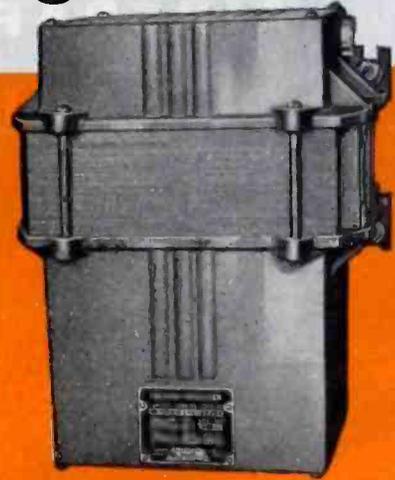
Greases—For lubrication of valves in high temperature or corrosive chemical services. Plug Cock Grease—for metal valves. Stopcock Grease—for glass and ceramic valves.

DOW CORNING

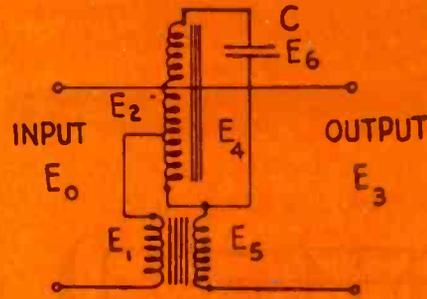
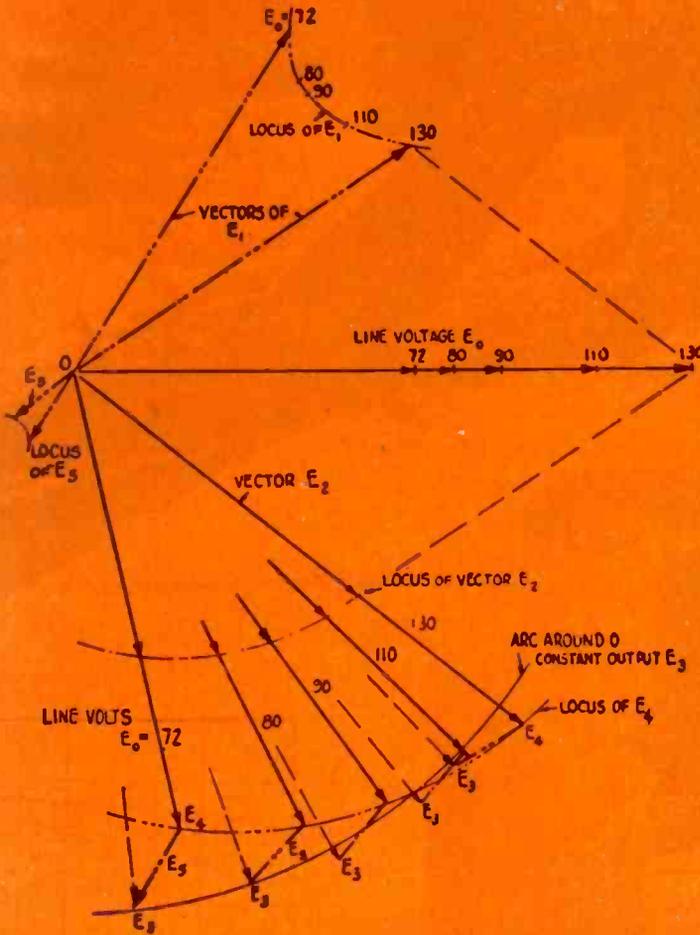
DOW CORNING CORPORATION, BOX 592, MIDLAND, MICHIGAN

Raytheon Voltage Stabilizers

CONTROL Output Voltage to $\pm 1/2\%$



Endbell Model



VECTOR RELATIONS FOR FULL LOAD AND VARIABLE LINE VOLTAGE

PRINCIPLES OF OPERATION

The stabilizer consists of two transformers with the primaries in series. One of these transformers operates at high magnetic density. This transformer with the higher saturation is partially resonated by means of a condenser. The secondary of the two transformers are connected in series opposed. Careful design results in the various voltages adding up vectorially producing the desired output changes compensating for differences of individual voltages. The resultant is a constant output voltage. This action is illustrated above

in the chart of vector relations of voltage.

A Raytheon Voltage Stabilizer . . . built into new equipment or incorporated into apparatus not having voltage regulation . . . improves the performance and assures reliable, accurate operation of the equipment. It stabilizes varying line voltages from 95 to 130 volts to plus or minus $1/2\%$. Entirely automatic in operation, the Raytheon Voltage Stabilizer has no moving parts, nothing to wear out. Simply connect it and forget it. Write for Bulletin DL48-537.



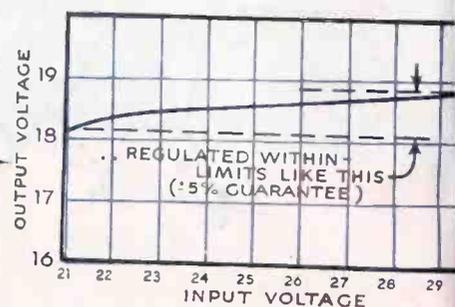
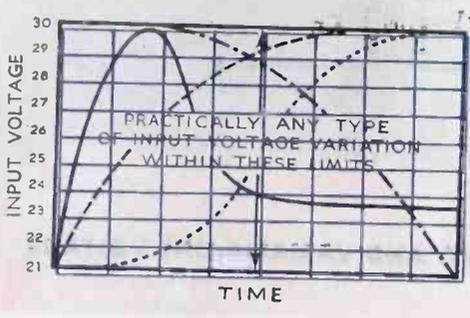
RAYTHEON
MANUFACTURING COMPANY
 190 WILLOW STREET, WALTHAM, MASS.

MANUFACTURERS OF VOLTAGE STABILIZERS, RECEIVING AND TRANSMITTING TUBES AND COMPLETE ELECTRONIC EQUIPMENT



The coveted Army-Navy "E", for Excellence in the manufacture of war equipment and tubes, flies over all four Raytheon Plants where over 15,000 men and women are producing for VICTORY.

HOW TO SMOOTH OUT AIRCRAFT VOLTAGE VARIATIONS



**BUY MORE
WAR
BONDS
NOW!**

VOLTAGE variations inherent in aircraft electrical systems may handicap the performance of precision electronic or other electrically powered devices you manufacture. If so, a Webster Voltage Regulator may solve the problem for you as it has for other manufacturers of airborne equipment. Tell us about your problem . . . we will be glad to analyze it for the applicability of Webster Voltage Regulators. No obligation, of course.

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TODAY**
Dynamotors and
Voltage Regulators

TOMORROW
World-Acclaimed
Record Changers

WEBSTER PRODUCTS
3825 W. ARMITAGE AVE.  **CHICAGO 47, ILLINOIS**

WHAT FREQUENCY RANGE

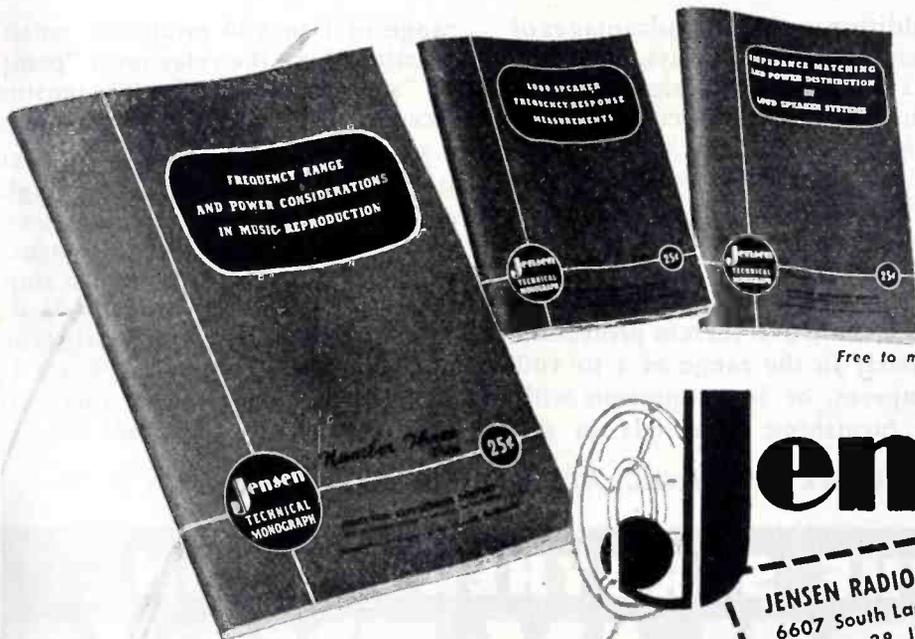
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"Frequency Range and Power Considerations in Music Reproduction" is the title of number three JENSEN Monograph, now ready for mailing. With the approach of FM, Television, High Quality Recording and other advances in the audio electric art, calling for new and increased emphasis on the requirements of High Fidelity Sound Reproducing equipment, this subject is both timely and pertinent.

Do you know the maximum, useful audio frequency ranges under actual listening conditions? Do you know how frequency range is limited even if perfect transmission, reception and reproduction were possible? Or how much change in high frequency cut-off is required to be just noticeable to the listener?

All of these questions, and many more, are answered in this latest JENSEN Monograph. Based on an extensive examination of authoritative work in this field, treatment of the subject is such that it will be found valuable by professionals, the trade, educators and the public.

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Chicago 38, Illinois

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(Check one, two or three. Send 25c for each book ordered.)

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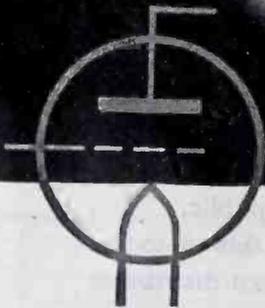
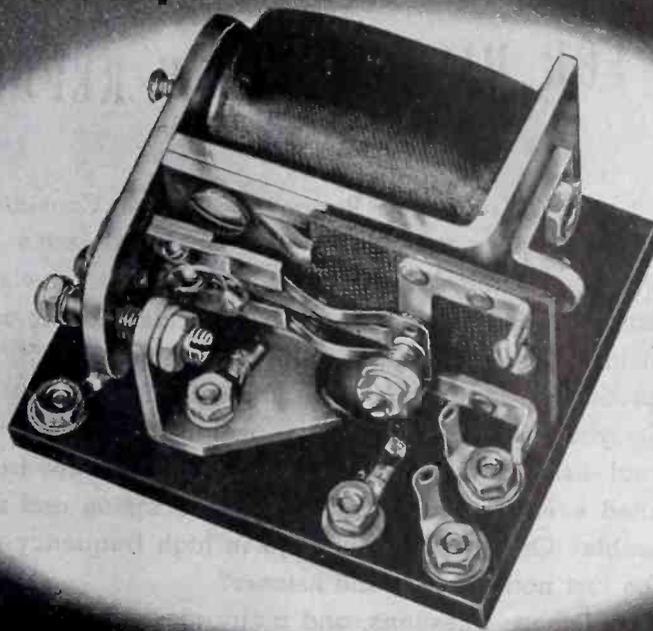
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STRUTHERS-DUNN

RELAY TYPE 79XAX



EXTREMELY CLOSE DIFFERENTIAL

... between pick-up and drop-out for either current or potential operation may be obtained by use of a resistor across the coil of the 79XAX, thus reducing coil current to a value just sufficient to hold the contacts closed. Any further decrease in current or voltage will operate the contacts.

Extreme sensitivity can also be obtained by use of a resistor, and the addition of a special coil to the 79XAX. These maintain the relay in a balanced condition. Any slight unbalance of the bridge or other power source will, through the upper coil, buck or boost the lower coil and cause the contacts to snap-operate.

Sensitive, Snap-Action Operation FOR USE ON SLOWLY-VARYING COIL CURRENTS

In addition to all of the advantages of conventional sensitive relays, Struthers-Dunn Type 79XAX is designed so that its armature practically completes its travel *before* the contacts snap-operate to the corresponding position. This, plus the fact that contacts remain closed *with full pressure* up to the instant of transfer, permit this relay to be used in a number of unusual ways. Such applications include overcurrent protection particularly in the range of 1 to 100 milliamperes, or in connection with shunts furnishing potentials in the

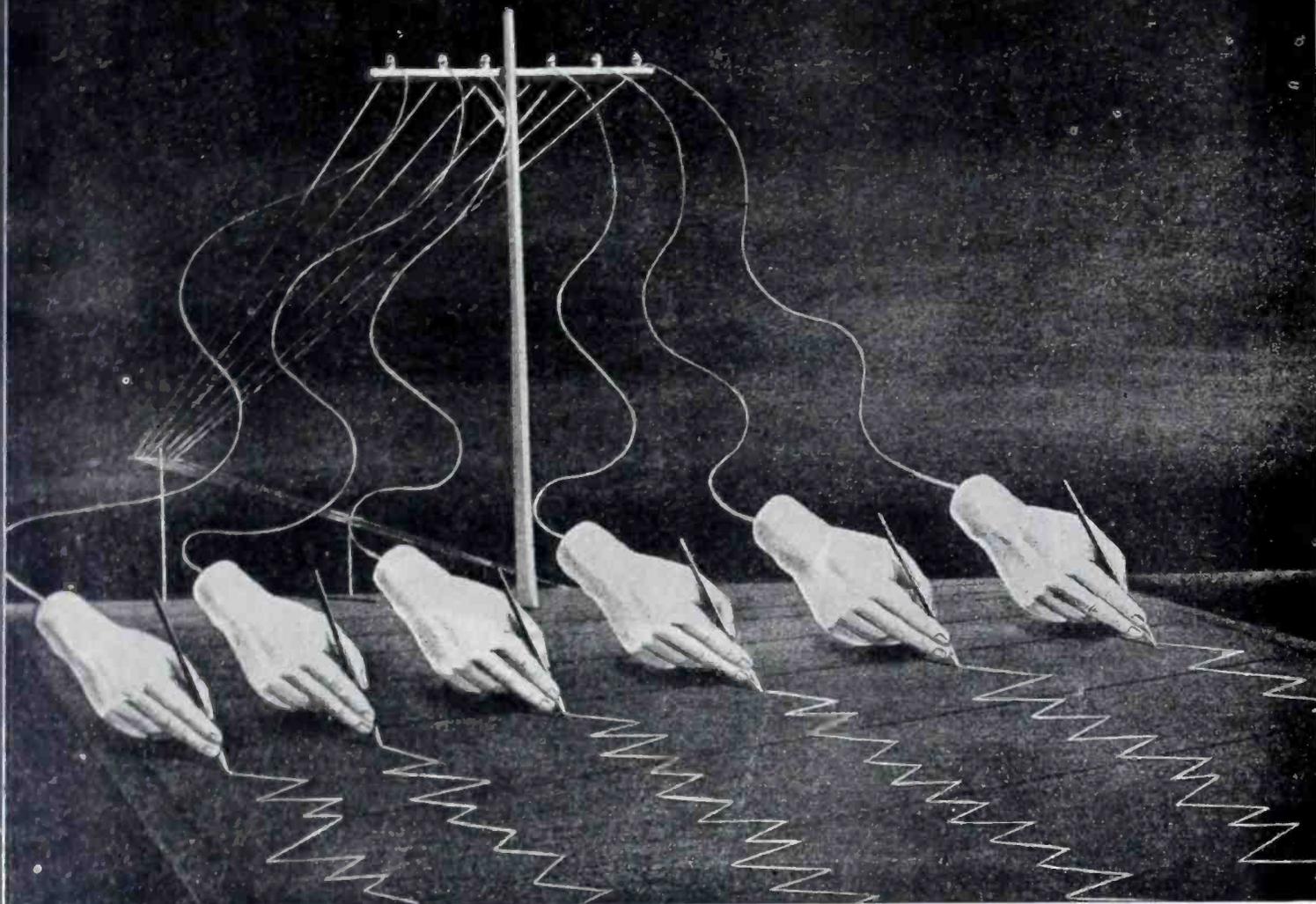
range of 1 to 100 millivolts; pulsing circuits where the relay must "pump" or "scratch its own back"; sensitive vacuum tube circuits, and various others.

Normal sensitivity is 0.01 watt, although this sensitivity can be heightened by means of various circuit arrangements. Contact arrangement is S.P.D.T., and contact rating 10 amps. 110-V a.c., and 10 amps. 24-V d.c. Balanced construction withstands 10 G vibration and shock. Write for Data Bulletin describing this relay and giving circuit diagrams.

STRUTHERS-DUNN, INC., 1321 ARCH STREET, PHILADELPHIA 7, PA.

ONE OF THE STRUTHERS-DUNN
5,288 RELAY TYPES

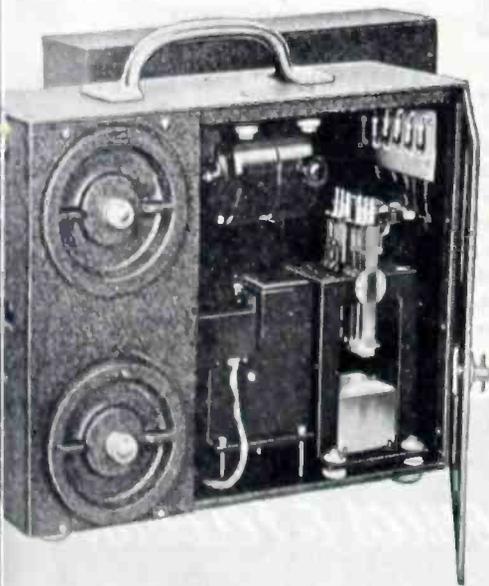
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FOR THE FIRST TIME IN HISTORY

Never before in the history of instrumentation has it been possible to obtain an extremely sensitive and accurate six channel Oscillograph, weighing less than 20 lbs., exclusive of battery, occupying less than $\frac{2}{5}$ of a cubic foot of space and selling for only \$1500. Suitable for all field and laboratory work it is particularly adapted, because of its sturdy construction, light weight and compactness, for use in aircraft in flight. Operates from its own or the plane battery. Sensitivity is such that many dynamic strains and vibrations can be recorded directly without amplification. Takes hundred foot roll of paper 2" wide operating at $1\frac{1}{2}$ " per second or 6" per second.

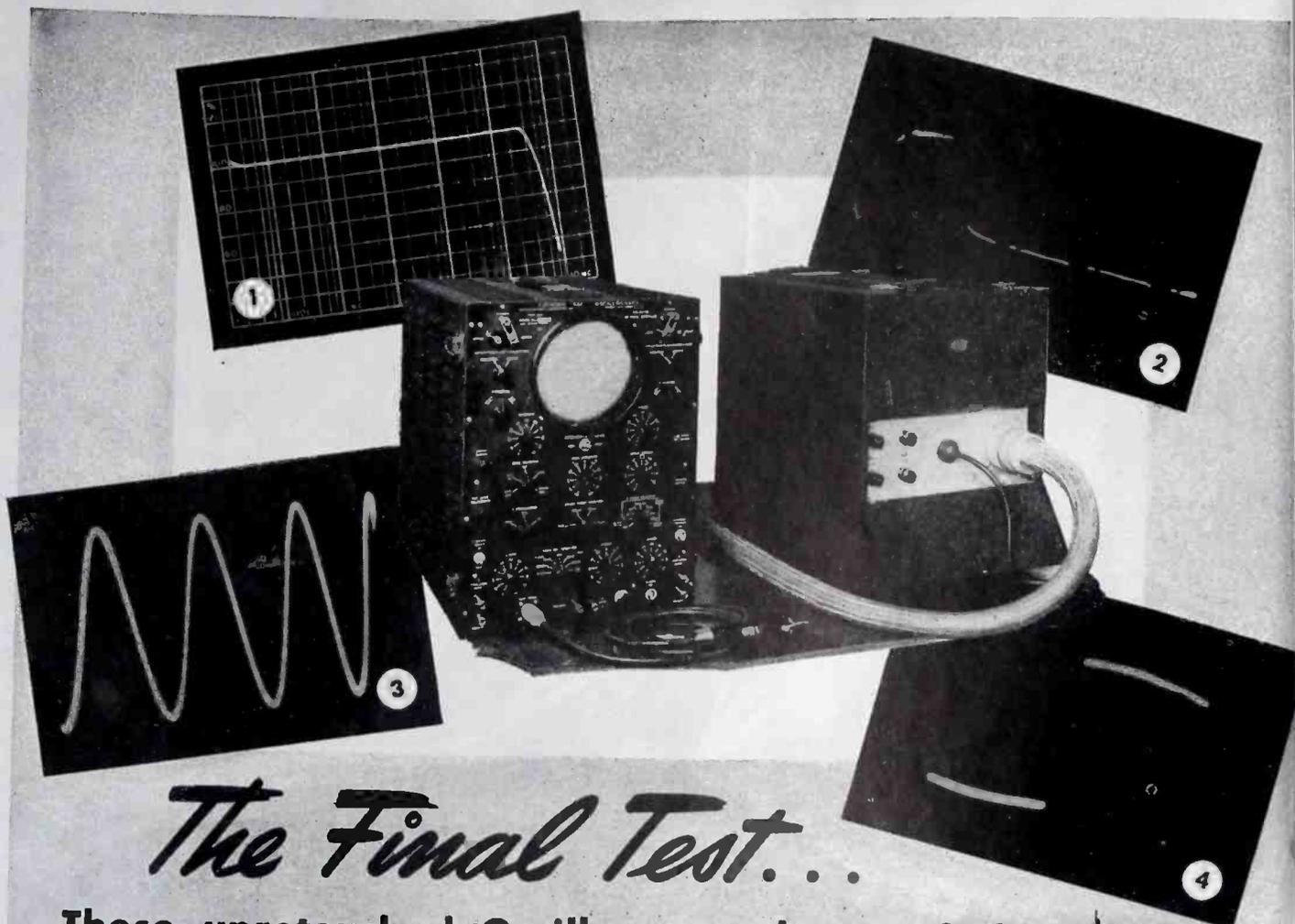
Write for further details.



complete line of indicating and recording instruments available.

WAUGH

Laboratories



The Final Test...

These unretouched Oscillogram photos of the DuMONT Type 248 Oscilloscope, tell the story best



◆ This is the DuMont Type 248 Oscilloscope. As is true of all other precision instruments, it must stand or fall by its performance. Because written specifications often give little indication of how well an oscilloscope meets today's critical requirements, we believe the accompanying unretouched photos cover points of particular interest to those who work with modern electronic circuits. To wit:

① Sinusoidal frequency response curve of the vertical amplifier. Free from irregularities. No rise caused by over-compensation at high end. Fall-off is gradual.

② The excellent transient response of this instrument is shown by absence of overshoot or other distortion in this pulse having

a rise time of about 1/10th microsecond. Here the driven (or "slave") sweep is triggered by the pulse itself, which is then delayed by a self-contained distortionless network so that the leading edge is not obliterated. The one microsecond markers (or others at intervals of 10 or 100 microseconds) are blanked into the trace by an internal marker oscillator. A beam-control circuit eliminates the bright spot of the beam rest position.

③ Continuous sweep circuit has a range when free-running of from 15 c.p.s. to 150 kc. When moderately synchronized with a signal of higher frequency, however, it will operate at much faster rates. This oscilloscope shows a one megacycle sine wave at a sweep frequency of approximately 300 kc. Return trace is normally completely blanked but may be seen if necessary by fully advancing the intensity control. Notice the

good linearity of this time-base as well as that of the driven sweep in (2).

④ Correct compensation at the low end of the frequency range is illustrated by almost distortionless transmission of a 30 cycle square wave through the vertical amplifier. Compensating circuits for both low and high frequencies are carefully adjusted for optimum phase characteristics.

All of which, together with other equally convincing characteristics, boils down to this: The DuMont Type 248 Oscilloscope, used on the bench or mounted on its matching streamlined truck, is an instrument without equal for laboratory, shop or production line.

◆ Write for Literature . . .

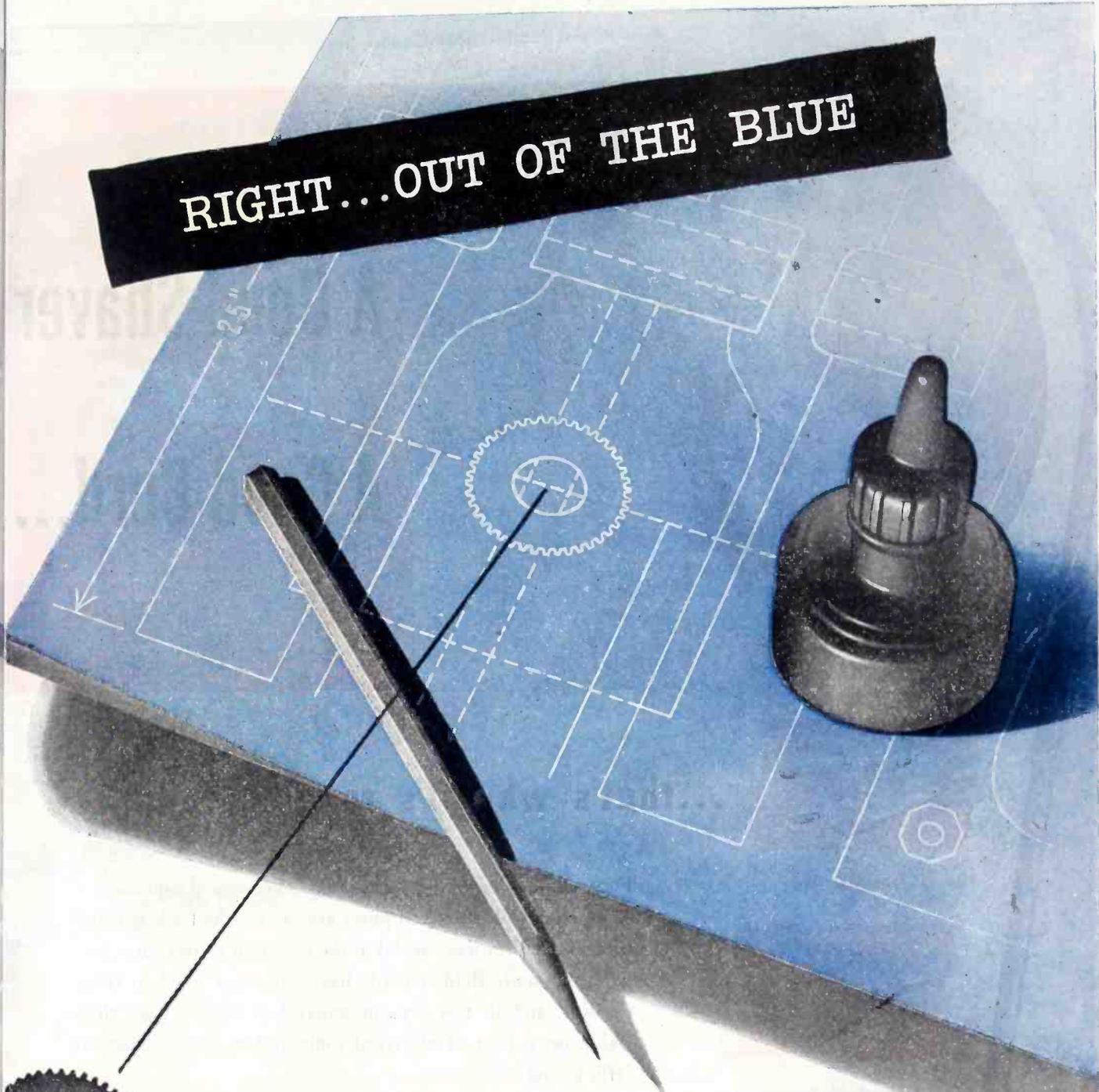
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DUMONT

Precision Electronics & Television

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY - CABLE ADDRESS: WESPXLIN, NEW YORK

RIGHT...OUT OF THE BLUE



Take a look at those blue-prints of post-war products you're going to manufacture. Ask your engineers, your draughtsmen, to point out the parts that are to be fabricated of Taylor Laminated Plastics. Those are the parts that will give you light weight with great strength . . . attractive appearance . . . unsurpassed insulating qualities . . . the characteristics required for extreme machining at high speeds . . . the necessary resistance to moisture and solvents . . . the economy of speedy mass-production that will be vital in meeting post-war competition.

Submit your blue-prints to Taylor with the confident knowledge that Taylor's recommendations will be right . . . out of the "blue." Do it now.

POST-WAR-PLANNING DEPARTMENT OF

TAYLOR FIBRE COMPANY

LAMINATED PLASTICS: PHENOL FIBRE • VULCANIZED FIBRE • Sheets, Rods, Tubes, and Fabricated Parts
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**A Good Shaver
PLUS
A Good Cord...**



Unbreakable Plugs



Unbreakable Connectors



Unbreakable Strain Relief

...that's why it's running today

For years an identifying mark of a good electrical appliance, Belden electrical cords and plugs are an accepted token that the manufacturer was careful in the selection of the parts for his equipment. Belden cords have promised freedom from Corditis, and in this present emergency have proved their value on a host of electrical tools and appliances that are still giving service.

After the war, customers will again look for nationally advertised Belden cords and plugs as a guide in purchasing electrical equipment. Take advantage of the plus value of Belden materials when designing your post-war products; specify Belden Corditis-free cords.

BELDEN MANUFACTURING COMPANY
4625 W. Van Buren Street, Chicago 44, Illinois

Belden

Corditis-free

CORDS



MOISTURE

the enemy of radio insulators CAN'T PENETRATE STEATITE

Moisture in hot steaming jungles and in cold foggy climates is a life-shortening enemy of radio equipment.

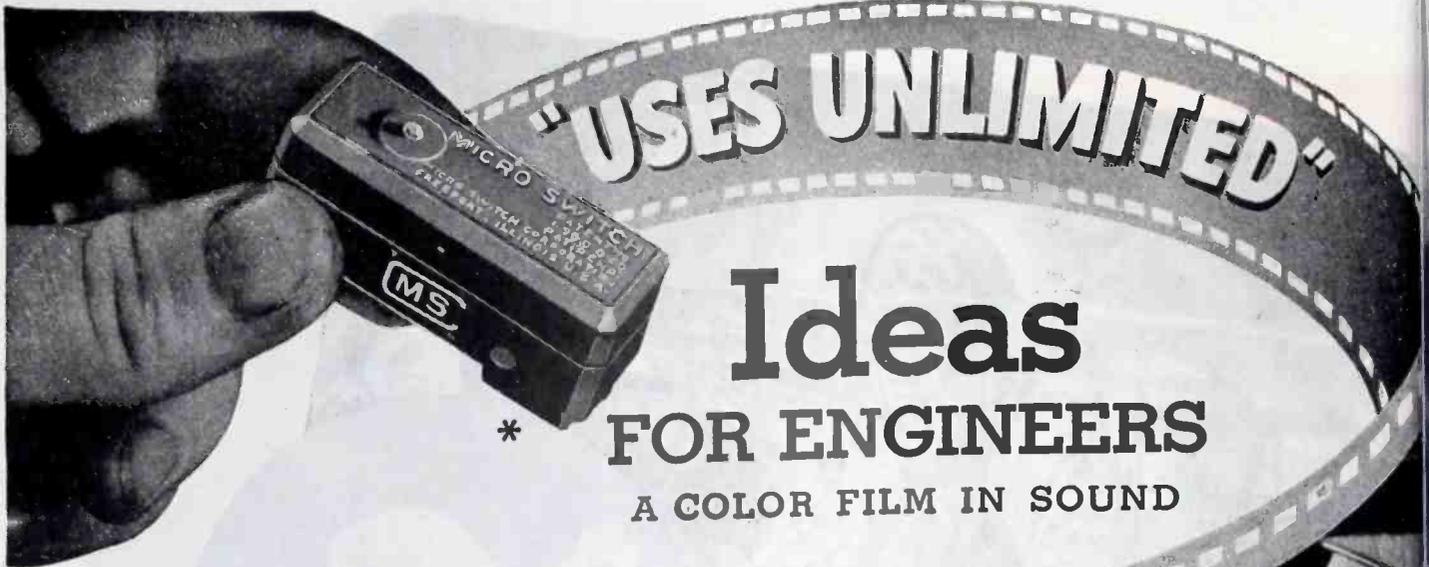
Steatite is absolutely impervious to moisture. The American Society of Testing Materials porosity test (Steatite placed in a chamber with fuchsine dye under five tons of pressure for six hours) has proved that General Ceramics and Steatite insulators are not porous and therefore do not absorb moisture.

The low loss factor, the high physical strength, the stability of shape of Steatite is not affected by age or climatic changes. For a long trouble-free life of your equipment specify Steatite Insulators made by General Ceramics & Steatite Corporation.



General Ceramics
AND STEATITE CORP.
 KEASBEY
 NEW JERSEY

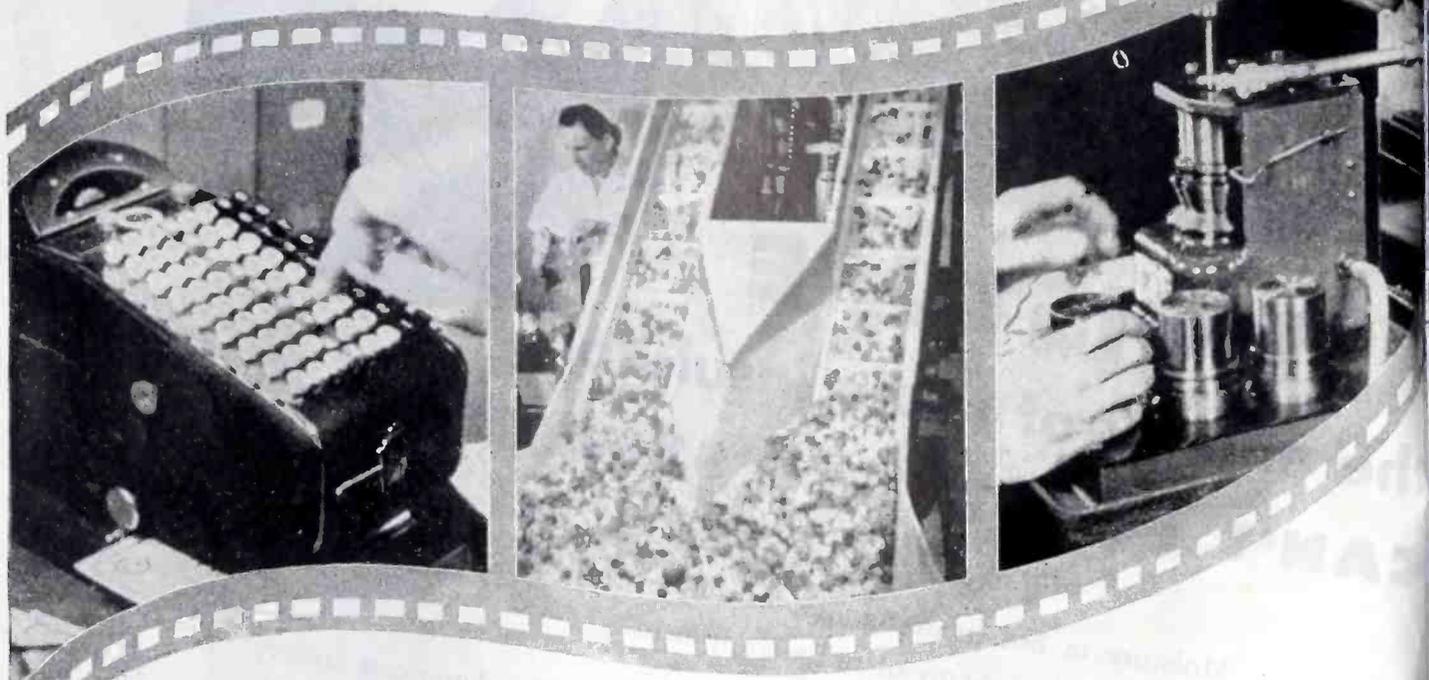
639



"USES UNLIMITED"

Ideas FOR ENGINEERS

A COLOR FILM IN SOUND



The fast-moving action, interesting color, and concise description in "Uses Unlimited" show how Micro Switches are made, and how they are being used by production and design engineers throughout industry to control everything from sensitive, precise instruments and office equipment to heavy duty machinery. This film is packed with examples of tried and proven applications of Micro Switches. It will stimulate the thinking of your engineers by showing them how

others have solved electrical control problems by the use of Micro Switches. "Uses Unlimited" is available to industrial groups, technical societies, training classes, schools and colleges. Size: 16 mm. Length: 40 minutes. Contact the Y. M. C. A. Motion Picture Bureau: 347 Madison Ave., New York, N. Y.; 19 So. La Salle St., Chicago, Ill.; 351 Turk St., San Francisco, Calif.

* The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision snap-action switch, Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate repeat performance is experienced over millions of operations. Wide variety of basic switches and actuators meets requirements varying from high vibration resistance to sensitivity of operating force and motion as low as 2/1000 ounce-inches. Many types of metal housings are available.

MICRO MARK
MS TRADE SWITC**H**
A DIVISION OF FIRST INDUSTRIAL CORPORATION

FREEPORT, ILL., U.S.A., Sales Offices in New York, Chicago, Cleveland, Los Angeles, Boston, Dallas, Portland, (Ore.)

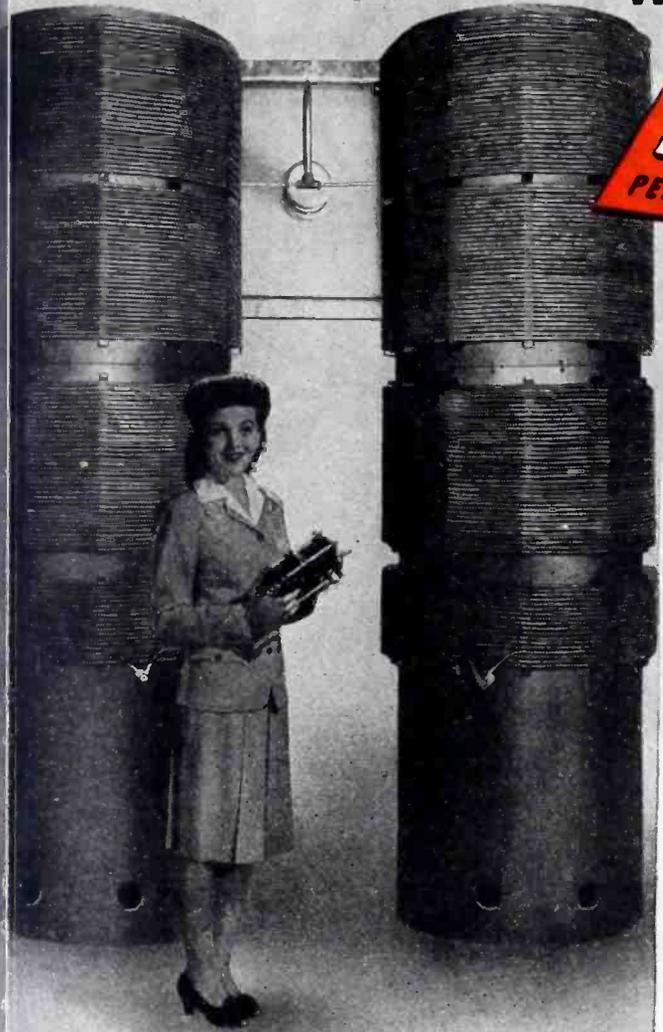
Let's All Back the Attack—
Buy EXTRA War Bonds



Build *higher* "Q" Inductances with

MYKROY

PERFECTED MICA CERAMIC INSULATION



Q Inductance
Losses

"Q" is high when losses are low. That's why Engineers at Federal Telephone & Radio Corp. build their inductance coils on MYKROY supports . . . to keep losses down to a negligible minimum! For MYKROY combines inherent physical stability with remarkably low loss characteristics at high frequencies . . . the ideal mechanical and electrical properties so essential for efficient performance in the high frequency magnetic fields to which coil bars are exposed.

Leading manufacturers of electronic equipment everywhere are now turning more and more to MYKROY for dependable high frequency insulation, since this *perfected mica ceramic* is proving to be one of the best and most usable insulating materials ever developed.

Don't let another day go by without learning more about it. Write for your copy of the **MYKROY Engineers Manual** containing the facts about this perfected insulation.



MYKROY is the outstanding choice at FEDERAL TELEPHONE & RADIO CORP. for insulating supports in all coils large and small. For coils up to 10" diameter MYKROY is available in solid rods or can be molded to requirements with pre-threaded surfaces. Illustration shows 10 KW Transformer coils and small 100 watt inductance . . . both built with MYKROY.

HERE'S TECHNICAL PROOF OF MYKROY SUPERIOR INSULATING PROPERTIES

*MECHANICAL PROPERTIES

MODULUS OF RUPTURE.....18000-21000 psi
DENSITY
Mohs Scale 3-4 BHN. BHN 500 Kg Load. 63-74
IMPACT STRENGTH.....ASTM Charpy .34-.41 ft. lbs.
COMPRESSIVE STRENGTH.....42000 psi
SPECIFIC GRAVITY.....2.75-3.8
THERMAL EXPANSION......000006 per Degree Fahr.
APPEARANCE.....Brownish Grey to Light Tan

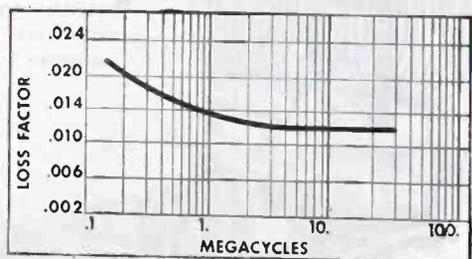
*ELECTRICAL PROPERTIES

DIELECTRIC CONSTANT.....6.5-7
DIELECTRIC STRENGTH (1/8").....630 Volts per Mill
LOSS FACTOR......001-.002 (Meets AWS L-4)

*THESE VALUES COVER THE VARIOUS GRADES OF MYKROY

GRADE 8. Best for low loss requirements.
GRADE 38. Best for low loss combined with high mechanical strength.
GRADE 51. Best for molding applications.

Special formulas compounded for special requirements.



Based on Power Factor Measurements made by Boonton Radio Corp. on standard Mykroy stock.

MYKROY IS SUPPLIED IN SHEETS AND RODS . . . MACHINED OR MOLDED TO SPECIFICATIONS

MADE EXCLUSIVELY BY **ELECTRONIC MECHANICS**

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Chicago 47: 1917 NO. SPRINGFIELD AVENUE . . TEL. Albany 4310

Export Office: 89 Broad Street, New York 4, N. Y.

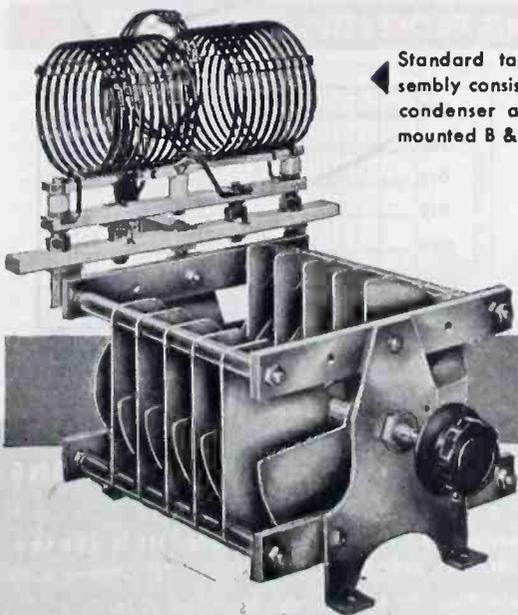
Here's VARIABLE CONDENSER Efficiency!

- Perfect electrical design symmetry.
- Built-in neutralization.
- Unexcelled mechanical construction.
- Built-in coil mountings with lead lengths at an absolute minimum.
- Half the length of conventional dual condensers.
- Unexcelled for use in balanced single-ended or push-pull circuits.

Write for new Catalog 75-C on B & W Type CX heavy duty variable condensers



▲ A B & W heavy-duty Condenser with 1/16" plates.



▲ Standard tank circuit assembly consisting of B & W condenser and integrally mounted B & W coil.

▲ Typical standard Type CX Condenser with 1/16" plates.

AIR INDUCTORS-VARIABLE CONDENSERS
ELECTRONIC EQUIPMENT ASSEMBLIES



BARKER & WILLIAMSON
Dept. A104, 235 Fairfield Ave., Upper Darby, Pa.

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FOR EVERY PURPOSE
RCP
TEST INSTRUMENTS

*this silent watchman
guards quality...*

Typical of important testing operations entrusted to RCP quality instruments are those in the Research Laboratory of Callite Tungsten Corporation, one of the country's leading manufacturers of metallurgical components. Here precision engineered tube components must meet exacting standards and test equipment must be reliable. The speed, accuracy and simplicity of operation which characterizes the RCP test instruments make them ideal for Callite's use.

MODEL 665 V.T. OHMMETER INSULATION TESTER

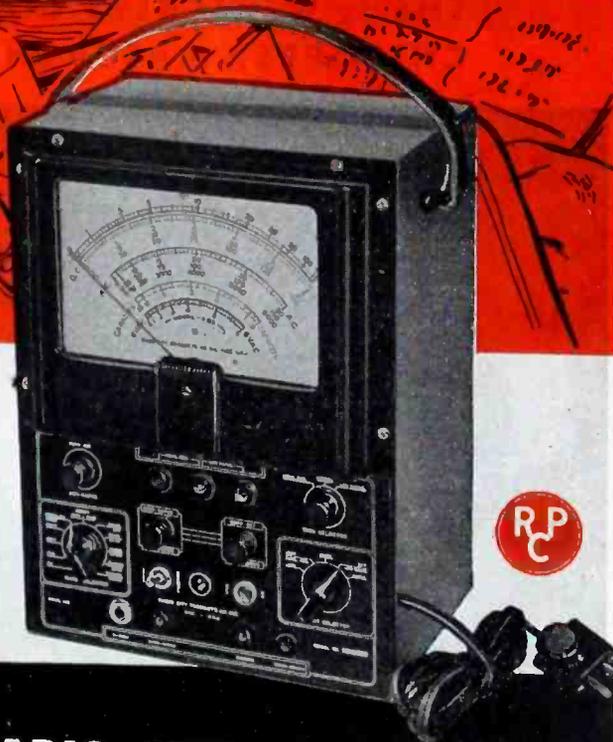
An outstanding example of advanced design plus flexible performance is the RCP Model 665—equivalent to 29 individual instruments in one... provides insulation testing at 500 V up to 10,000,000,000 ohms (10,000 megohms) with two other features—an electronic multimeter and a capacity meter

measuring as low as 0.0000025 mfd. (2.5 micro microfarads) and up to 2,000 mfd. Wide scale on 8" D'Arsonval Microammeter with guaranteed accuracy of 2% at full scale. Linear meter movement. Voltage measurements AC and DC to 8,000 volts. Maximum protection against burnout. Complete \$79.50.

Other RCP instruments which conform to Government specifications or are recognized as "standard" are described in our Catalog No. 128. Special instruments designed for unusual requirements.

REASONABLE DELIVERIES ARE NOW BEING SCHEDULED

Manufacturers of precision electronic limit bridges... vacuum tube voltmeters...
milliammeters... signal generators... analyzer units... tube testers...
oscilloscopes... and special instruments built to specifications.



**RADIO CITY PRODUCTS
COMPANY, INC.**

127 WEST 26th STREET NEW YORK 1, N. Y.

Our Customers wrote this Postwar Plan

Our Customers, old and new, have learned many things about Sickles' capacity to produce in wartime. Their experiences as reported to us, indicate clearly the role Sickles will play in their peacetime production.

1. Our Old Customers say that they were delighted with the speed with which Sickles met their wartime demands, got *quantity* up, kept *quality* up, and met *delivery* promises.
2. Our New Customers, many of whom had never before used a subcontractor for parts and components, say that they found our facilities *competent, flexible, economical*. They made no sacrifice in the closely guarded quality of their product. Result — many of them expect to continue to use Sickles' facilities, after Victory.

To add our customers' experience to our own and get a clear and workable postwar plan, was a simple matter:

When the demand for wartime communications parts and products has abated, and the need for similar peacetime products rises, we will reconvert to peacetime production as smoothly as we converted to war. We are ready.

Yes, our plan is as simple as that. You, our customers, wrote it. You can begin to use it at any time your plans have reached the specification stage. Just say when.

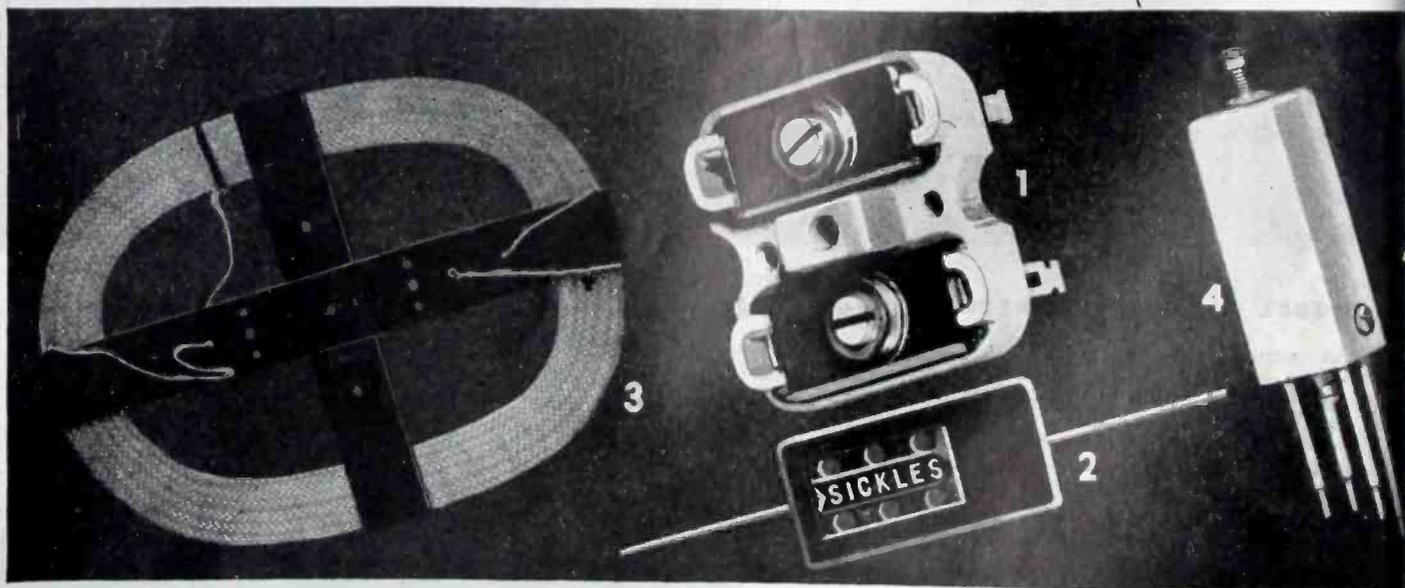
THE F. W. SICKLES COMPANY
CHICOPEE, MASSACHUSETTS



SOME SICKLES FIRSTS

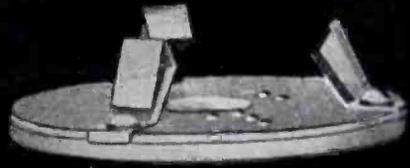
1. 1933—Dual Mica Trimmers*
2. 1936—Silver Cap Condensers*
3. 1940—Low-loss "Ripple" Loops*
4. 1941—Midget I.F. Assemblies
5. 194V—More Coming

* Patented



Radio and Electronic Specialties for Today and Tomorrow
SICKLES

G-E MYCALEX was selected



because of its imperviousness to moisture and economy of



fabrication for this **OUTDOOR PORTABLE BEACON**

G-E MYCALEX was chosen for the socket of the G-E Novalux Portable Flashing Beacon for three reasons: First—the performance of this amazing material under high humidity conditions; second, because of guaranteed high mechanical strength of at least 14,000 lbs. per square inch; third, it eliminates expensive molds. G-E mycalex can be fabricated from sheets with common machining operations.

In addition, G-E mycalex has chemical and dimensional stability. It does not deteriorate with age and is free from warpage and shrinkage. It offers high resistance to sudden temperature changes.

Whatever your specialized insulation needs may be, it will pay you to investigate this all-purpose insulating material. For a list of specialists in the fabrication of G-E mycalex — for a free sample and a copy of the data bulletin, "G-E Compression-Molded Mycalex"—please fill out the coupon. . . . *General Electric, Schenectady, N. Y.*

• Tune in General Electric's "The World Today" and hear the news from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday evening listen to the G-E "All-Girl Orchestra" at 10 E.W.T. over NBC.

**FREE—
G-E MYCALEX
BULLETIN**



**ELECTRONICS
DEPARTMENT
GENERAL
ELECTRIC CO.
Schenectady, N. Y.**

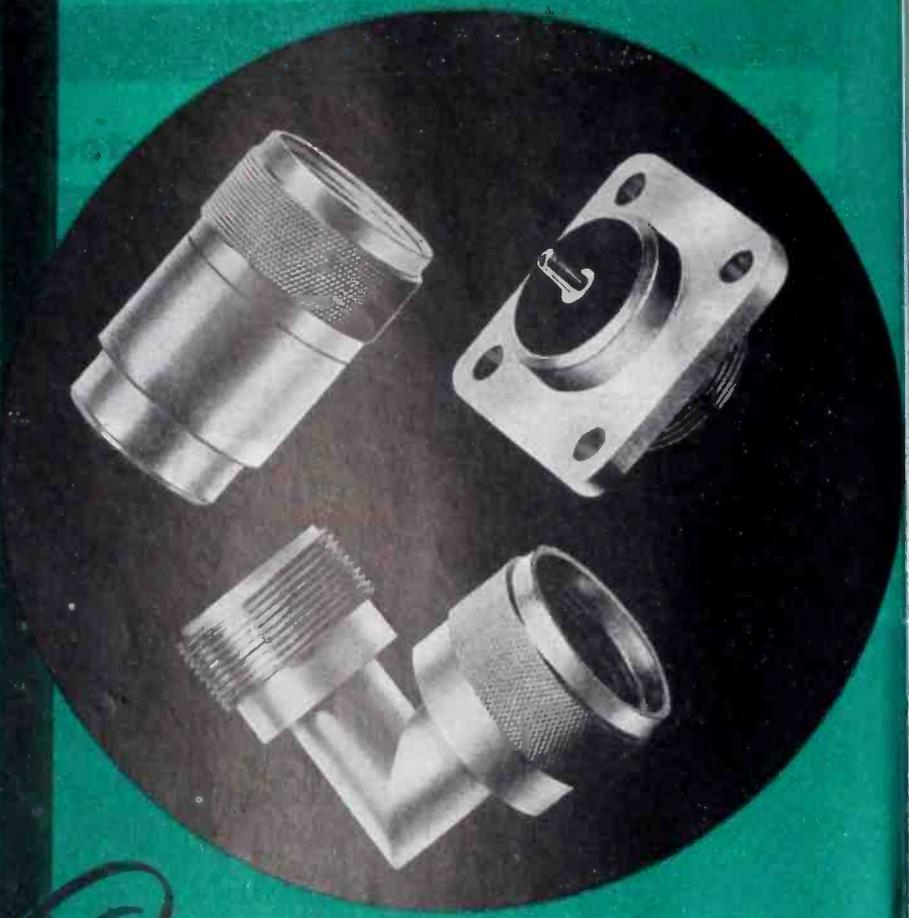
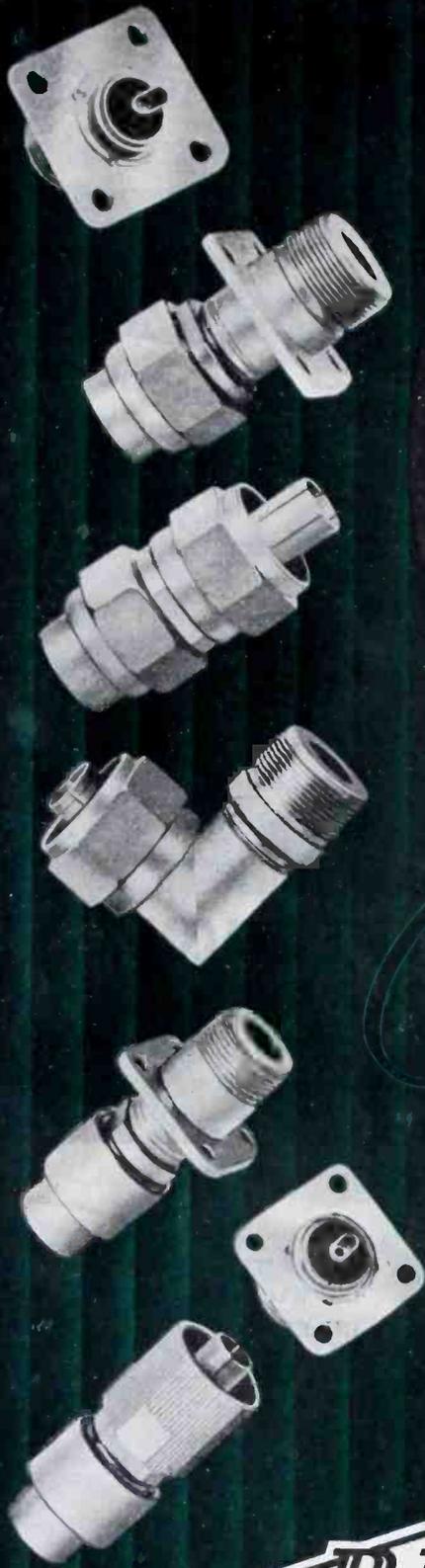
Please send me a free sample of G-E mycalex and your descriptive bulletin explaining the methods and tools to use in machining G-E mycalex.

(If you wish a list of fabricators of G-E mycalex, check here _____.)

Name _____

Company _____

Address _____



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WITH **DICO**

COAXIAL CONNECTORS TO "AN" SPECIFICATIONS
Performance-proved in specialized high-frequency applica-
tions — where only the finest is acceptable — DICO co-
axial connectors are now available for additional service

to the electronic industry. A catalog
will be furnished at your request;
please give type designations of
the connectors you require



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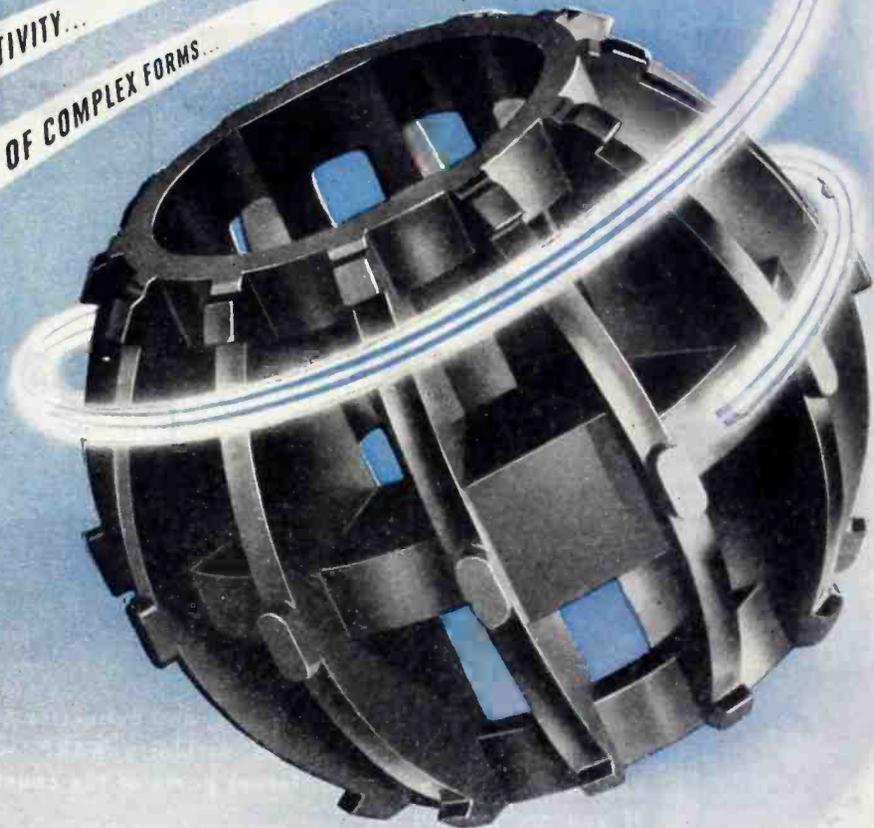
BAKELITE

TRADE-MARK

MOLDABILITY...

HIGH FREQUENCY RESISTIVITY...

STRUCTURAL STABILITY OF COMPLEX FORMS...



INVISIBLE FIRST WINDINGS

The low power factor of coil forms molded from BAKELITE low-loss phenolic material (.015—.025 at 60 cycles; .010—.014 at 10^3 cycles; and .007—.009 at 10^6 cycles) is practically unchanged after a day's immersion in water. Their dielectric constant at all frequencies is 4.7—5.2. The high volume resistivity inherent in this plastic (above 10^9 megohm centimeters) drops but slightly with increased temperature.

Modern high-frequency radio coil forms are molded from BAKELITE low-loss phenolic plastic. Ribbed spherical forms—4 x 5 inches in size, and 13 ounces in weight—these forms have electrical characteristics ideal for use in high frequency circuits below 30 mc. They are also dimensionally stable, resistant to high humidity, and are unharmed by the heat generated in the operation of radio equipment.

These radio coil forms show that BAKELITE low-loss phenolic material can be readily molded into complicated shapes. It offers many possibilities for the fabrication of insulating parts designed for high fre-

quency apparatus—always contributing, in addition to its other properties, the advantages of compactness, strength, and light weight.

Investigate this BAKELITE material now—for today's essential requirements and for consideration in your postwar planning. Write Department 7.



BAKELITE CORPORATION, 30 E. 42 St., New York 17, N.Y.

Unit of Union Carbide and Carbon Corporation



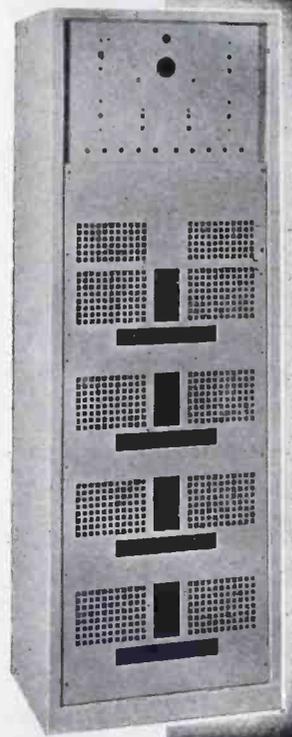
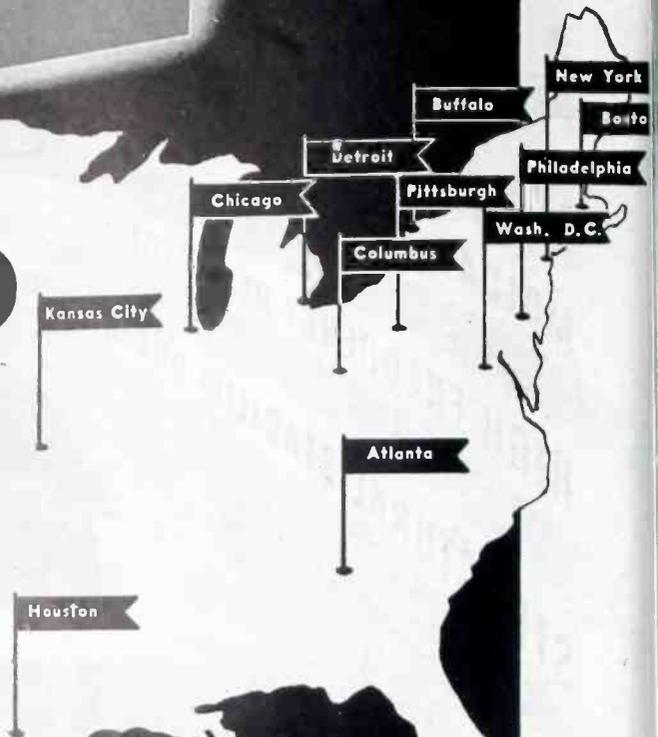
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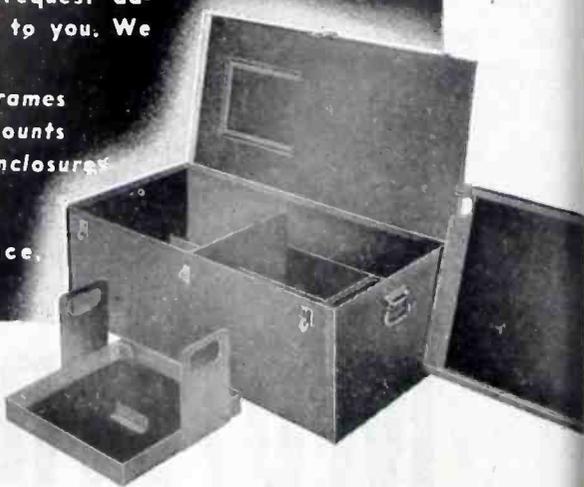
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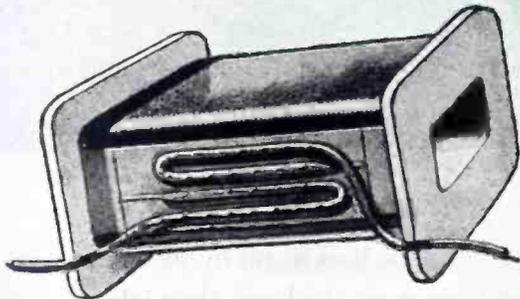


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Electrical Insulation



resists the
**BLACK HAND
 OF CORROSION**



The logic behind the growing use of Lumarith insulation is extremely simple: The primary cause of the free acids associated with electro-chemical corrosion is moisture. Lumarith resists moisture, and contains no materials which combine with moisture to form free acids.

Besides, Lumarith doesn't promote that built-in hazard common to much electrical insulation—organic decomposition.

Even where corrosion ordinarily is severe—as with coils on positive D.C. under moisture conditions—Lumarith is dependable. It is outstanding for high dielectric strength and its high softening point (146–177° C. depending on formulation) makes it applicable in many types of coils.

How is Lumarith available? Films, sheets, rods, tubes and molding materials. Films are furnished plain or with special mat finish, easy to see and

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You'll want a copy of "Lumarith for the Electrical Industry." Send for it now. Celanese Celluloid Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.

Data—	Softening Point	Dielectric Strength	volts/mil.
P903	146° C.	2800–3300	
P904	177° C.	2800–3300	
P904 can be baked 8 hours at 140° C. in a coil.			

Lumarith*

A CELANESE PLASTIC

WE READ BETWEEN THE BLUEPRINT LINES



PLASTIC MOLDERS can look at a prospective job from two angles. They can take the blueprint you supply, figure their methods, materials, costs and deliveries exactly as indicated. That is, they can read just the lines on the blueprints.

AT GENERAL INDUSTRIES, we do more. Naturally, you know the functions of the plastic part better than we do, so we don't attempt any major design changes. *But we do know plastics*, and from our wide experience can make suggestions which come from reading between the lines of the blueprint.

QUITE OFTEN, our customers have found that our ideas result in a product improved in utility or appearance, delivered quicker and at a lower final cost.

THIS METHOD calls for wide experience in the plastic industry. It requires a real knowledge of mold making and of the characteristics of the many different plastic compounds. And, of

course, it must be backed up by modern equipment and operators who know their jobs.

SO, when you are thinking of postwar plastic parts, we suggest that you ask us to "read between the blueprint lines." Right now, we're 100% on war work, but when that job is done, we'll have engineers and facilities to take on your peacetime plastic molding. We'd like to have you call on us.



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Molded Plastics Division • Elyria, Ohio

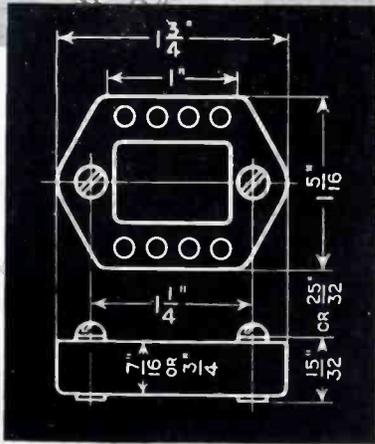
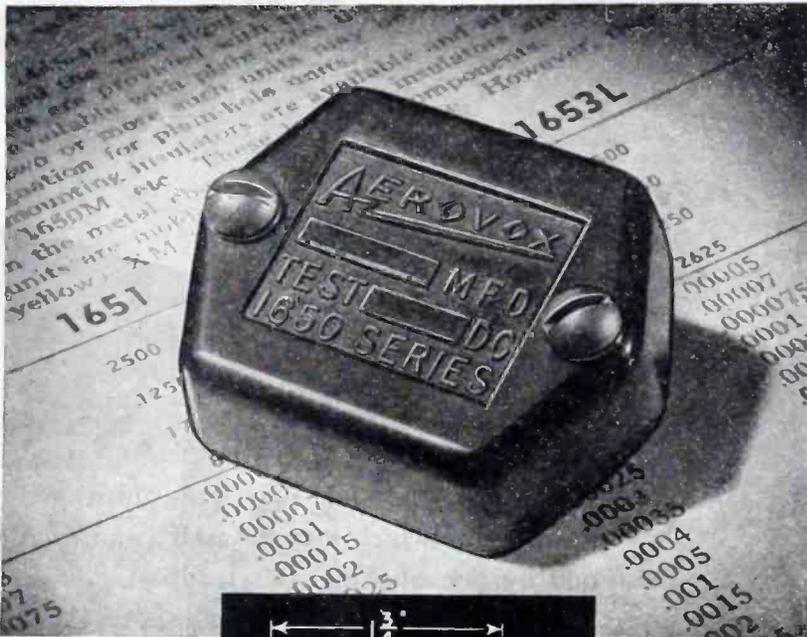
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In ratings from 1000 volts to 10,000 volts test . . .

Molded-in-Bakelite

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● The 1650 Series is the most rugged of the heavy-duty molded-in-bakelite mica capacitors of the extensive Aerovox line. These high-voltage units are intended for the most critical service of low-powered transmitting circuits, buffer stages, power amplifiers, laboratory equipment, etc. Also recommended for use in ultra-high-frequency circuits, and accordingly their r.f. current ratings are given in the Aerovox Capacitor Catalog.

The extra-generous use of high-grade dielectric material provides that greater factor of safety for longer service under severest operating conditions.

Standard units with tapped holes take 6/32 screws which serve for terminals. Also available with clearance holes through which screws or rods may be slipped, so that two or more units can be stack-mounted. Low-loss ceramic mounting insulators are available for mounting on metal surfaces. Standard units molded in brown bakelite. Also available in low-loss (yellow) XM bakelite.

In 1000, 2500, 5000, 7500 and 10,000 volts D.C. test. Capacitance ratings from .00005 mfd. to .06 mfd. in Type 1650 at 1000 v. D.C. test; .00005 mfd. to .001 mfd. in Type 1654L at 10,000 v. D.C. test.

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GENERAL ELECTRONICS' new Transmitting Triode is a medium power tube which may be used as an oscillator or modulator. Designed by one of America's leading, pioneer tube engineers, it offers many unusual qualities—operates up to 30 megacycles; exceptionally rugged design; three pillar grid support; anode almost totally encloses grid and filament—an essential feature for operation at ultra-high frequencies; grid terminal at side reduces inter-electrode capacitances—important in high frequency circuits.

Available now—get top performance in the 808 through General Electronics' superior engineering!

GET HIGH WATT-VALUE
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24 G

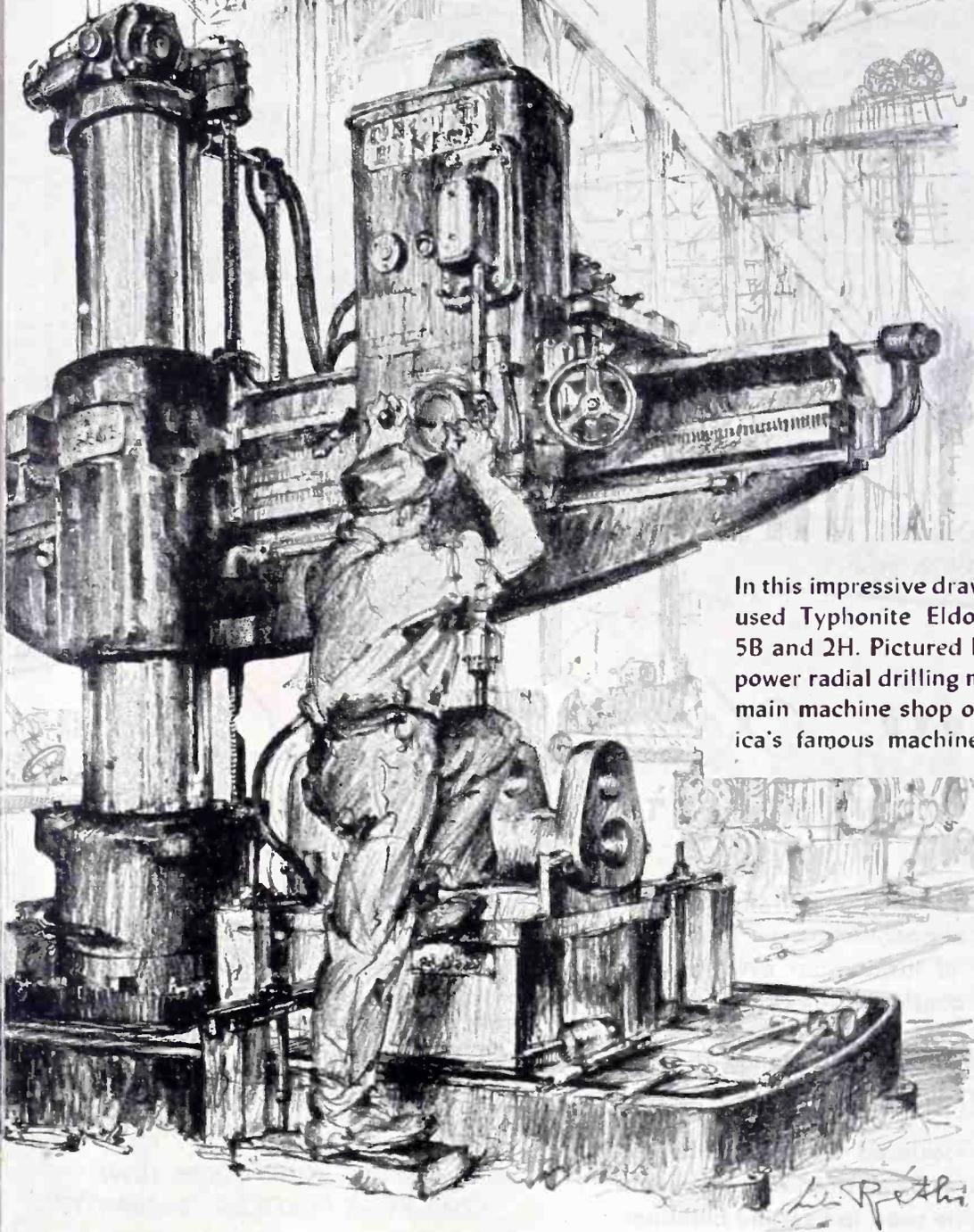


90 watts continuous output (as a Class C, unmodulated UHF amplifier) from this amazing tube that weighs only 1.5 ounces . . . and at 3 meters! Output of 65 watts even at 1.5 meters (200 Mc). No insulators or supports to evolve gas on the first overload; no exposed filament to spray envelope with energy-wasting electrons; tantalum plate and grid eliminate flashed-film type getter, allowing tube to run cooler; well adapted for pulse operation where very high voltages are applied in instantaneous pulses . . . all these are features that recommend General Electronics' 24 G to your consideration.

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Here's the Work of a Great Drawing Pencil!



In this impressive drawing, the artist used Typhonite Eldorado, degrees 5B and 2H. Pictured here is a high-power radial drilling machine in the main machine shop of one of America's famous machine tool makers.

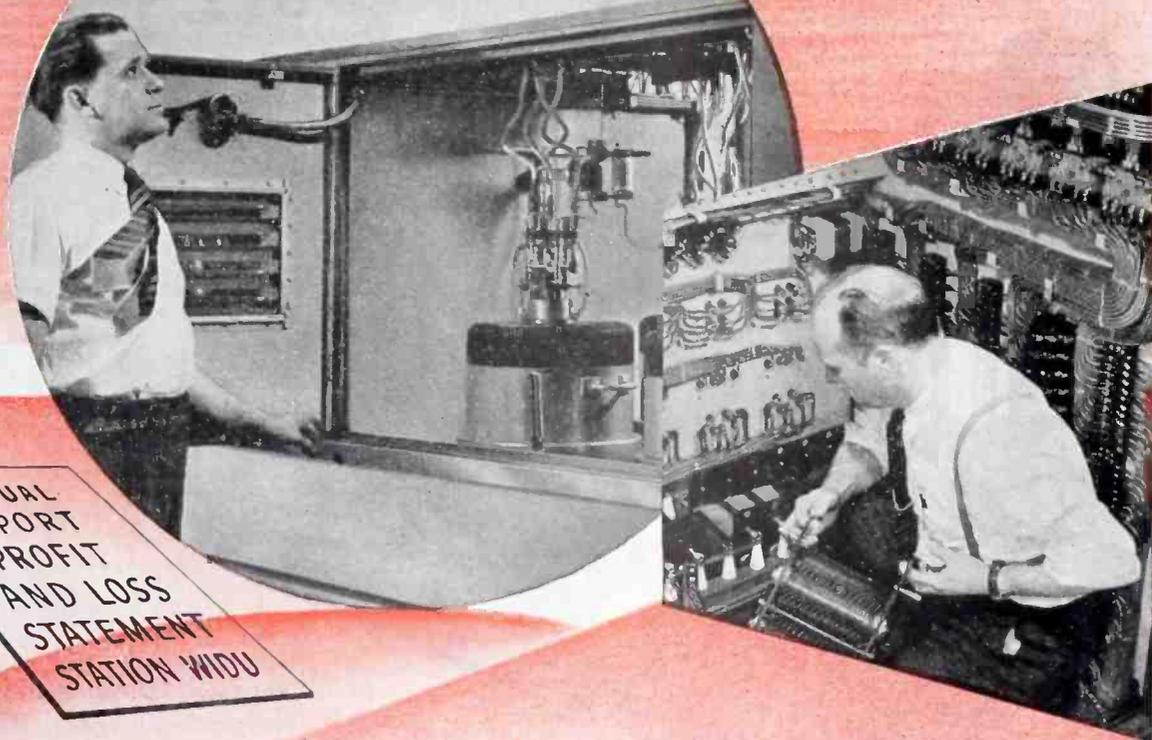
You'll agree that the proof of a drawing pencil's superiority lies in ease of use and excellence of results. By those standards, the best drawing pencils in the world are made in America. Today, it is impractical—and old-fashioned—to bow to the name of any foreign-made pencil. Try America's best—Typhonite Eldorado!

TYPHONITE ELDORADO

PENCIL SALES DEPT. 59-J10. JOSEPH DIXON CRUCIBLE COMPANY, JERSEY CITY 3, N. J.

ELECTRONICS — October 1944

DIXON'S TYPHONITE ELDORADO-- HB



CONSIDER *Low Operating Cost*
WHEN YOU SELECT A NEW TRANSMITTER

In selecting a new transmitter, naturally you will take a good, hard look at operating costs. They have an embarrassing way of turning up every month where they *have* to be considered.

Westinghouse Transmitters are designed to keep operating costs at a very low minimum. For example:

1. Air-Cooled Tubes—featured by Westinghouse, eliminate the expense of water cooling. Air which cools the tubes can be used to heat the building.
2. Metal Plate Rectifiers—also featured by Westinghouse, seldom require replacement. Their life is practically unlimited.
3. Conservative Operation of All Tubes—results in long life and low upkeep cost.

4. Class C Operation—of all radio frequencies provides higher efficiencies and lower power consumption than any other type of circuit.

These are only a few of the advantages Westinghouse Transmitters offer. Others include: *Simplicity of Control, Continuity of Operation, High Fidelity Signals, Ease of Maintenance.*

**PLACE YOUR ORDER NOW
 FOR YOUR POSTWAR TRANSMITTER**

By placing your order today for a Westinghouse transmitter, you assure yourself of the fastest possible delivery following the lifting of wartime manufacturing restrictions. We are scheduling deliveries in the sequence in which orders are received. For details write Westinghouse Electric & Mfg. Company, Dept. 1NB, P. O. Box 868, Pittsburgh 30, Pa.

Westinghouse RADIO DIVISION
 PLANTS IN 25 CITIES ... OFFICES EVERYWHERE

A M • E L E C T R O N I C S • F M





WHAT SHOULD A TELEVISION STATION COST?

Prospective station owners are fast discovering that DuMont has *the answers on television* . . . and willingly shares its "television know how" for the advancement of this magnificent new art. Prospective station operators also are discovering that DuMont telecasting equipment is "tops" in signal transmitting efficiency and effectiveness, and leads in installation and operating economies.

Eloquent evidence of DuMont leadership is provided in the design and construction of 3 of the nation's 9 television stations in service today . . . and in the operation (for more than 3 years) of Television Station WABD, New

York. Just as DuMont's development of the DuMont Cathode-ray Tube made television commercially practical, so DuMont pioneering in station design and operation has set a pattern for profitable station management. This pattern is available to you.

"Planning Your Television Station" tells how to insure a low-cost telecast operation . . . outlines your equipment requirements . . . offers you a surprising arrangement for *reserving* equipment now, and for custom-building your telecasting set-up and training your personnel soon after victory. Please request this booklet on your firm letterhead.

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Precision Electronics and Television

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MODEL 50A RECORDER

TURNER 211 DYNAMIC BROADCAST TYPE

Utilizing a new type magnet structure and acoustic network, Turner 211 extends the high frequency range and raises the extreme lows from 2 to 4 decibels — to compensate for overall deficiencies in loud speaker systems. Unique diaphragm structure results in extremely low harmonic and phase distortion without sacrificing high output level. A reliable unit for use in war plants, P. A. Systems and broadcast studios.

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Illustrated Catalog



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- less vibration
- less noise
- trouble-free torque bearings
- lower upkeep

GENERAL SILENTBLOC

Rubber Mountings and Bearings
Absorb Vibration... Allow Torque Action
...Correct for Misalignment



SILENTBLOC MOUNTING to control vibration from motor, cushion shock loads, isolate vibration between parts of equipment or isolate delicate instruments and controls from foreign vibration. Engineered design determines rate of deflection in any plane.

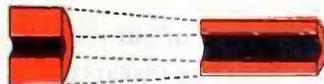
YOUR customers expect improvements in your new products—and General Silentbloc can help you deliver them. These shear-type mountings, bearings and couplings are engineered to:

1. Control vibration and cushion shock loads.
2. Give trouble-free torque action.
3. Correct for misalignment in hinges, bearings and shaft mountings.

Silentbloc are simple in construction, easy to install and practically indestructible.



SILENTBLOC TORQUE BEARING lasts as long as the machine, never needs lubrication, makes no noise, cannot slip. Degree of torque is engineered into the bearing by experienced General designers.



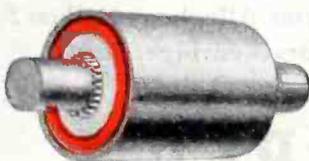
Before Assembly After Assembly

They consist of an outer metal tube into which a rubber ring is inserted under pressure, with a sleeve or shaft "shot" through the ring. This patented process *elongates* and *confines* the rubber, the

extreme tension giving a cohesion of rubber-to-metal which cannot rupture. The stretched rubber stays *alive* and resilient.

Silentbloc mountings and bearings can be engineered by General to solve *your* exact problem. They are made any size, to carry loads of ounces to tons. Any metal—steel, bronze, aluminum, magnesium—can be used. By variation of size and design, elongation and distortion of rubber and kind of rubber, Silentbloc can be made to give *predictable performance* under axial, radial, conical or torque loads.

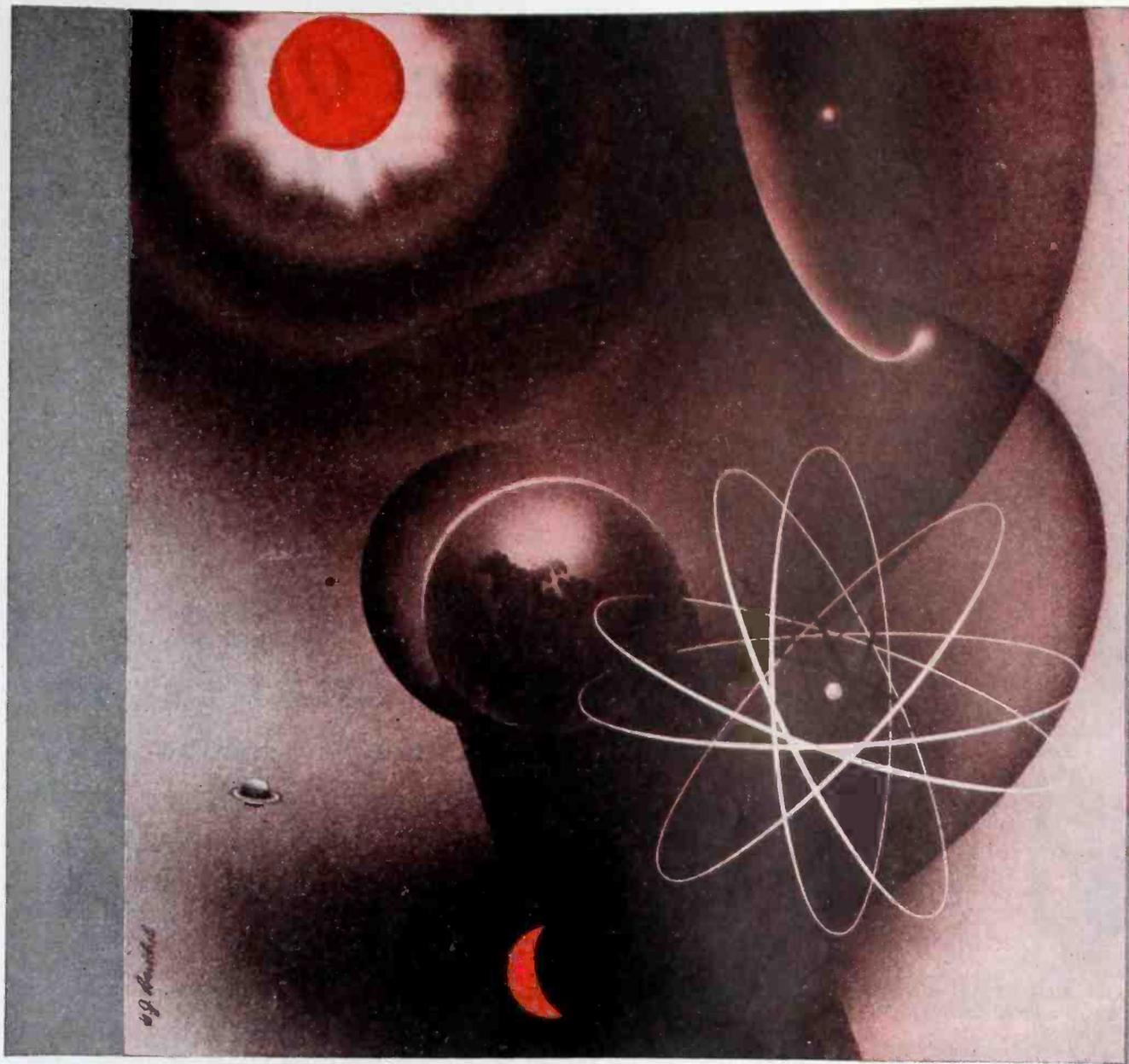
Silentbloc efficiency has been proved in automotive products, aircraft, industrial machinery, home equipment, electrical products, marine equipment, and war mechanisms. To learn how it can improve your product, write now for factual booklet. The General Tire & Rubber Company, Dept. 93, Wabash, Indiana.



SILENTBLOC BEARING provides a cushion for needle or ball bearings, shaft supports in series, and hinges, which corrects for misalignment. Saves time and money in production, gives longer life and lower upkeep.



THE GENERAL TIRE & RUBBER CO.
Mechanical Products Division, Wabash, Indiana



Electronic Futures ARE AS LIMITLESS AS SPACE

**But... IT TAKES
Special
Electrical
Alloys
TO TRANSLATE
FANCIES INTO
FACTS**

As alloy steel specialists, one of our jobs for many years has been the researching and commercial development of special electrical materials—highly individualized alloys which have helped many a designer to realize in fact what he hoped for in theory. We developed a number of these materials, and some of them are at the heart of the war's most valuable contributions to the electrical and electronic sciences of the future.

The Allegheny Ludlum line of finely developed silicon steels, high-permeability and high-resistance alloys, and glass-to-metal sealing alloys is most complete. What's more, it is backed by exhaustive data on characteristics and performance, and amplified by full technical cooperation. •Whatever you want to do, electrically or electronically, let us work with you. Allegheny Ludlum Steel Corporation, Brackenridge, Pa.



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Supplier to the Electrical Industry

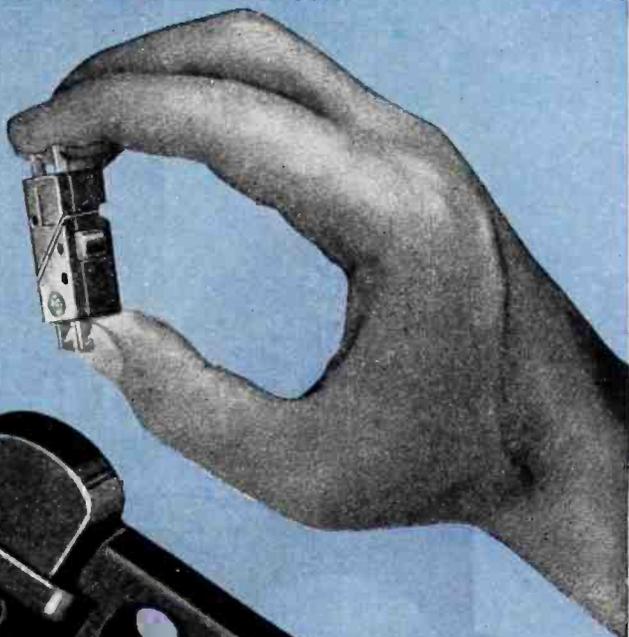


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The G-E Switchette

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BECAUSE of its unusually small size and light weight, its lightning-fast snap action, and its long life, the G-E Switchette is becoming more and more popular with designers for circuit control where space is at a premium.

Switchettes are available in ratings up to 10 amperes at 24 volts d-c (230 volts a-c), are provided with soldering terminals for wiring. They meet government specifications covering corrosion and vibration resistance, and operate at altitudes up to 50,000 feet and in ambient temperatures from 200 F to -70 F.

More than 200 modifications have already been developed to meet special circuit requirements and to fit into special mechanical arrangements. Dimensions, operating characteristics, and ordering directions for standard Switchettes and many typical modifications are given in our new catalog, No. GEA-3818C. For your copy, mail this coupon. If you don't find the forms you need in the catalog, our engineers will be glad to work with you in adapting Switchettes to meet your requirements.

GENERAL  ELECTRIC

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● Here's an inside view of the tiny, versatile G-E Switchette, enlarged to show you the double-break contact construction, which makes possible many ingenious wiring arrangements to solve tricky circuit problems. This is a standard form for controlling one normally open and one normally closed circuit. Variations of this arrangement are available to provide control of a single circuit, either normally open or normally closed. Other modifications include a form for simultaneously opening two circuits and closing one, or vice versa; also single-break forms for more sensitive operation.



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GENERAL ELECTRIC COMPANY, SECTION A676-141
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Please send me Bulletin GEA-3818C giving dimensions, ratings, and operating characteristics of Switchettes

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F.O.B. FACTORY

CARRIER FREQUENCY RANGE:
7.6 to 330 mega-cycles plus or minus 2% direct-reading in 5 bands, 6th band available for use with blank coil form supplied.

MODULATION:
Internal modulation, 1000 cycles; external modulation up to 20,000 microvolts; 0 to 60% direct-reading modulation meter.

VIDEO OR PULSE MODULATION:
Can be pulse modulated externally with signals having very steep wave length.

VOLTAGE REGULATED POWER SUPPLY:
115 to 230 volts, 40 to 60 cycles, single phase.

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Held to a minimum by improved shielding and R.F. filters.

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Calibrated attenuator continuously variable from 1 to 20,000 microvolts; accuracy plus or minus 10%.

(Manufactured by arrangement with the General Radio Company of Cambridge, Massachusetts, and in accordance with their designs.)



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Proof of the superiority of FEDERAL'S advanced manufacturing techniques and long-term experience in the field is found in this dramatic achievement. Difficult as the assignment was, we have successfully met all Army and Navy requirements for these precision laboratory instruments—thus permitting us to now make them available under priorities to research laboratories and manufacturers engaged in industrial electronics. Your inquiries will be given immediate attention.

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pioneer for tomorrow

The world of tomorrow will be one of electronics. Pioneer for that world is the electronic engineer. His vitally important effort during this wartime period in devising electronic equipment is helping to defeat the enemy. Tomorrow, he devotes his specialized scientific knowledge to aid peacetime industries.

Raytheon is applying its efforts to the development of advanced electronic tubes and equipment for the war effort. When that job is done, the knowledge that has been gained will be used to guarantee that post-war radio, industrial and electronic equipment manufacturers will receive Raytheon tubes and equipment with even greater "Plus-Extra" quality.



RAYTHEON

Raytheon Manufacturing Company
ELECTRICAL EQUIPMENT DIVISION
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ARMY-NAVY "E" WITH STARS
Awarded All Four Divisions of Raytheon for Continued Excellence in Production

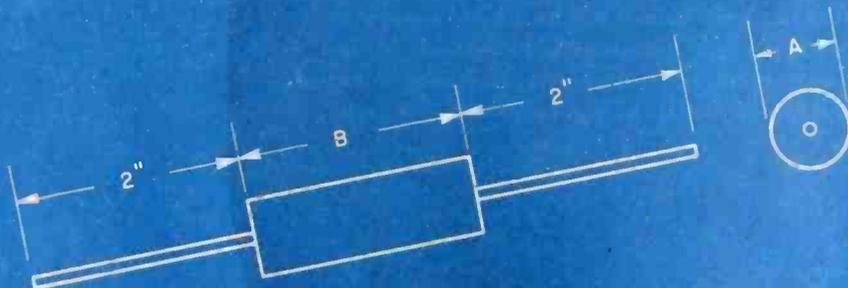
DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES AND EQUIPMENT FOR THE NEW ERA OF ELECTRONICS

MEMO TO *Purchasing Dept.*

In our postwar radio sets, recommend you buy Solar Sealdite Tubular Capacitors - they're the best we've ever tested - the only way-molded units - superior protection against moisture.

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49A40-4	S-0224	.02	600	7/16	1-5/8
49A40-5	S-0230	.05	600	9/16	1-5/8
49A40-6	S-0240	.1	600	9/16	2-1/8

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CAPACITORS &
ELIM-O-STATS



The Economic Reconstruction of Europe

THE time is fast approaching when allied and enemy populations alike will demand a blueprint for the economic reconstruction of Europe. The peace plans following this World War will be written piecemeal, and by experts, at a series of continuing conferences, such as Hot Springs, Bretton Woods, Dumbarton Oaks and Quebec, each tracing a new pattern for negotiation and each dealing with a single, specific problem. In the drawing of these plans, the United States, as owner of more than half of the world's industrial capacity, controller of the only great credit reservoir, and possessor of the largest force of highly skilled technicians and management engineers, has heavy responsibilities which its industrial, financial, agricultural and labor leaders cannot evade.

☆ ☆ ☆

Just what is the problem which the world's business leaders must help solve in Europe?

The best safeguard of peace is economic opportunity—a good chance for all peoples to raise their standard of living by their own ingenuity, foresight and industry.

Frustrated and disappointed peoples, who view the future with misgiving rather than hope, breed emotional demagogues who seek to divert nations from their ills and disappointments by promising military glory and conquests.

Consequently, an important step in building a secure and lasting peace is to open the doors of opportunity to the peoples of Europe.

The greatest obstacle to opportunity in Europe has been economic nationalism.

The economic tradition of the Continent always has been highly nationalistic. The national feeling generated by the first World War, and the political autonomy conferred upon many peoples by the peace treaties, led to a great growth of economic restrictions. This trend was accentuated by the depression and by the military plans of the Fascists and Nazis. Hitler had to show his people they could be fed even if a blockade was imposed again. The inevitable result of these influences was to carry self-efficiency to tragic extremes.

Economic nationalism holds down the standard of living of Europe in two ways:

- It prevents the rise in most European countries of low-cost mass production.
- It operates against an efficient geographical division of labor, preventing nations from doing what each can do best.

Great machines require great markets. One great machine of which the United States has many and Europe few is the continuous strip steel mill. At the outbreak of the war we had twenty-eight such mills of various sizes, England but one, and Continental Europe one. A building containing one of these machines is more than a quarter of a mile long and the minimum cost of the mill is almost \$25,000,000. Only the prospect of a mass market justifies production on this vast, but highly economic basis.

The wasteful geographical distribution of production is shown by the agricultural policies of Italy, France and Germany.

In the 1930's, when lard sold for less than 8¢ a lb. in the United States, it cost 32¢ a lb. in Germany. In Italy and Germany imports of wheat were banned and its production at home was heavily subsidized. By the middle of the 1930's, wheat sold for \$1.55 a bushel in France, \$1.97 in Czechoslovakia, \$2.29 in Germany, and \$2.47 in Italy. At the same time the United States and the other efficient world producers and exporters (Canada, Australia and Argentina) were *restricting* production and were unable to average more than about 75¢ a bushel for their wheat.

Economic unity in Europe must ultimately mean a freedom to trade not greatly different from what we have within the United States. Given economic unity and the large markets which go with it, efficient mass production will develop. With Europe receiving cheap supplies of such staple foods as wheat, pork, lard and dried fruits from overseas, European farmers can prosper by specializing in producing fresh foods—butter, cheese, eggs, fruits, vegetables.

Then European agriculture will be more prosperous producing its specialties, and our agriculture (and that of the other great efficient surplus-producing countries as well) will have greatly expanded markets for our staples.

With a cheaper food supply for Europe—yet one yielding a better price for our agriculture—European labor will live better. Labor now used uneconomically for agricultural production will be released for industry. With big machines and semi-automatic processes European labor can produce more steel, automobiles, furnaces, plumbing and electrical appliances to advance its standard of living in coming decades, as the United States has done in past decades.

A rising standard of living in Europe will bring

Europeans to view peace with optimism and hope. And world trade grows as confidence and prosperity widen.

☆ ☆ ☆

How would a Europe which possesses economic unity appear to us on this side of the Atlantic?

It would be a prosperous Europe that would have strength in its advancing industries, but as the single great agricultural deficit area of the world, it would be dependent upon overseas supplies for vital agricultural staples. This dependence upon overseas agricultural supplies would be greatest for industrial Germany. Some people believe that a strong Europe would be a threat to world peace. More important, however, is the fact that a strong and prosperous Europe would not be a frustrated Europe. It would have found a way to achieve a rising standard of living. Furthermore, a prosperous Europe would, economically, be a dependent Europe because, although the European industrial worker would use more and cheaper food, he would have it only as long as he maintained the peace.

A prosperous Europe would be of special advantage to American agriculture (if we do not keep on pricing ourselves out of the market) and of great advantage to American industry.

The British policy of buying agricultural staples from abroad, for example, made her, a nation of only 45,000,000, the purchaser, in 1937, of \$250,000,000 of all kinds of agricultural products from the United States. In the same year the rest of Europe (exclusive of Russia), with a population of 325,000,000 purchased only \$300,000,000 of our agricultural products. But with more sensible organization of its agriculture, Europe could be expected to buy more than one billion dollars of agricultural products from us.

By far the greatest market for an expanded European industry will be Europe itself.

For American industry, there will be growing markets in Europe as industry expands. Experience shows that the trade between different highly industrialized areas is large. This country's biggest export markets have been with its keenest competitors—Britain, Canada, Japan, France and Germany.

Before the war, Europe, with two and one-half times the population of the United States, had only one-sixth as many automobiles.

If Europe (exclusive of Britain and Russia) were to motorize proportionately, it would need 75,000,000 automobiles. With normal depreciation this would ultimately mean 10,000,000 cars to be produced annually to replace worn out cars.

If one still wonders about the immense number of things Europe might produce for herself, let him calculate the highway expenditures, the filling and repair station businesses that must be equipped and maintained; and the doubling of the steel production that would be required to make the automobiles themselves and to reinforce with steel even a moderate amount of additional concrete highways.

Another example is the electrification of Europe. With two and one-half times our population Europe's

consumption of electrical energy would be 175 million electrical H.P., if the European worker were to have the advantage of as many H.P. as the American. Yet, just prior to the war, Europe's installed operating capacity was only about 40 per cent of this figure.

☆ ☆ ☆

What has been sketched for Europe is actually much more nearly a page from the economic history of the United States than it is mere prophecy about a desirable future for a Europe at peace. But how can it be achieved? And what is our part to be in helping to bring it about?

Economic unity can be provided for the sovereign states of Western Europe by the peace treaty or treaties adopted at the end of the war. The provisions for securing *economic unity* in Europe should specifically cover:

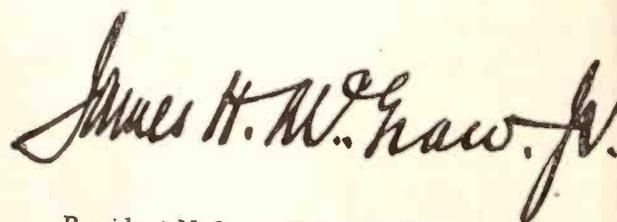
1. Substantial freedom for persons and enterprises to do business anywhere in Europe.
2. Reasonably free movement throughout Europe of persons for employment, recreation and education.
3. Greatly increased freedom of trade:
 - a. Within Europe—through the application of a Europe-wide agreement reducing the tariffs among all European countries to a maximum of 10 or 15 per cent.
 - b. With the rest of the world—through reduction of European tariffs on goods bought from overseas. This would call for generally lower levels on manufactured goods, and for the removal (after a reasonable period of progressive reduction) of tariffs on all agricultural foodstuffs and most industrial raw materials.
4. A special currency provision requiring as nearly as practicable complete currency stabilization for all countries of Western Europe among each other.
5. Creation of an agency (with adequate revenues) through which all Europe-wide business and other affairs affected by these agreements would be administered for a minimum period of twenty-five years.

This would permit the economic unity of Europe to be substantially achieved. During this period, assistance in administering the provisions would be given by officials of the United Nations.

Near the end of such a period arrangements could be made for a vote in the European countries on whether or not to continue the "unification provisions." If the vote were in the negative, the United Nations would have proper warning that additional safeguards would be necessary to prevent war.

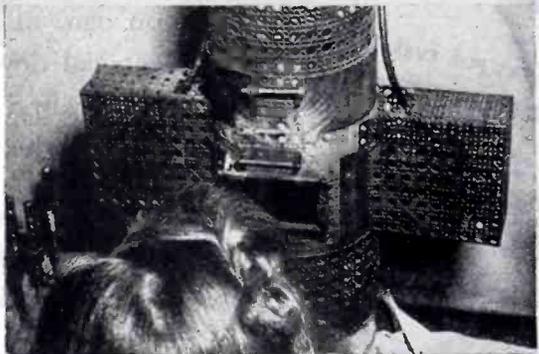
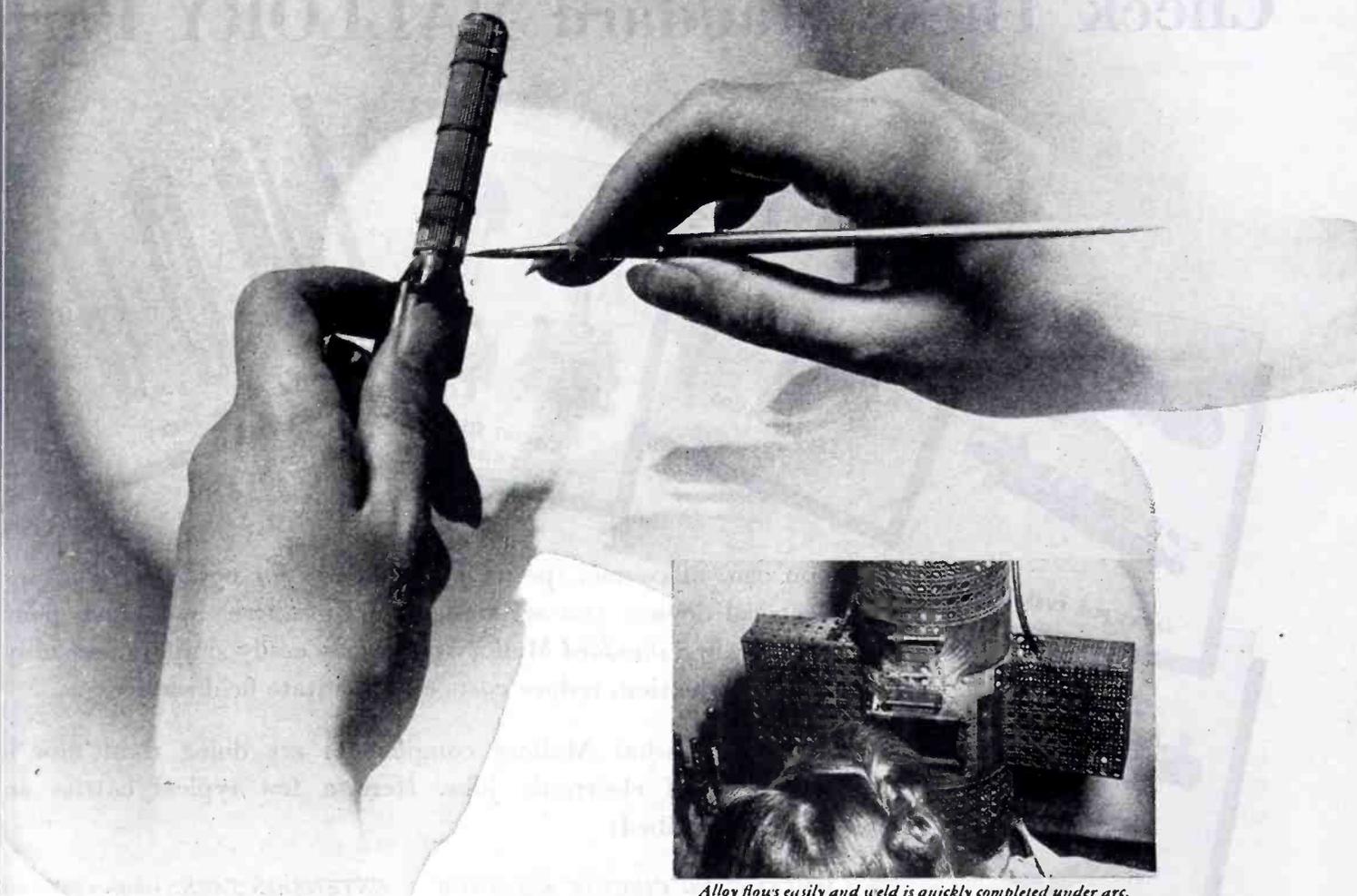
The suggestions made in this statement aim at securing economic unification of Europe and thereby promoting the possibilities of permanent peace in Europe.

The realization of these possibilities throughout the postwar years requires a freely expressed public opinion in Europe to guide all who share the responsibility for bringing peace to Europe and to the world.



President McGraw-Hill Publishing Company, Inc.

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This is but an example of the application of the science of metallurgy in the "science behind the science of electronics." The extent to which Eimac Engineers can solve this relatively small problem reveals two important facts:—(1.) The thoroughness of Eimac Engineering, and (2.) The completeness of their engineering facilities. The leadership which Eimac tubes enjoy throughout the world in all phases of electronics is a result of the soundness of this engineering.

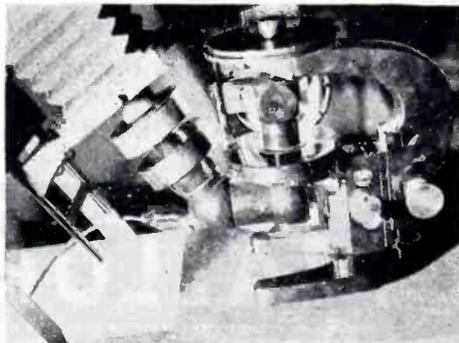
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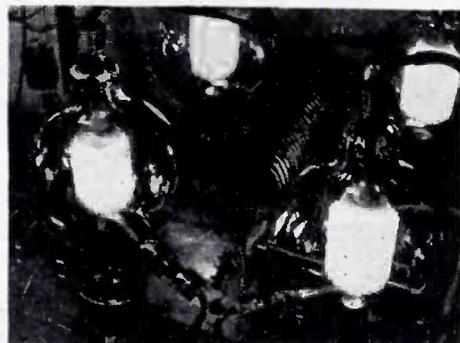
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CROSS TALK

LEGITIMATE . . . For the first time in many years, the editor has been sandbagged into going to the theater. It was quite an experience, and not altogether to be recommended to anyone out of practice. In the first place, in the legitimate theater, in case you have forgot, the orchestra is right down in front, between the audience and the singers or actors. There is only limited volume control, apparently, so that half the time the orchestra drowns out the singers. In the second place, the singers and actors are only natural size, not blown up real big as in a movie, and they are located down in front instead of up in front. Theater seats are so arranged that you can see around nearly everyone except the people in the row right in front of you, and these people always want to be right when you look right and vice versa. The result is, you seldom see much but the edges of the stage. There is also a fairly unsatisfactory acoustical arrangement so that it is difficult to make out the words without a libretto or something.

Some steady radio listeners and movie-goers complain that the drums and violins always seem to come from a certain part of the pit in the regular theater, but we didn't mind this so much—although it did sound strange. Others complain that the bass isn't loud or boomy enough but, on this score, maybe the fellow who plays the bass viol will, in time, make it sound like a radio. People do like bass, you know.

RESONANCE . . . Disappointment stares into the faces of members of the legal profession who look to the end of the war as a time to make their fortunes fighting patent infringement suits based on everybody's use of everybody else's patents. With the aftermath of the last World War in mind, when claims to the tune of some two billion dollars arose, Government has acted early and wisely this time to circumvent difficulties of this nature.

In a few cases exorbitant sums were asked for the privilege of using patents or inventions to aid in the war. These offers were flatly refused and the claimants then had the opportunity of taking the matter to the Court of Claims. As a result, most of these get-rich-quickers have been scaled down so that the Government gets the use of the inventions at a reasonable cost. It looks, then, as though the infringement suits

which took so many years to settle after the last World War will not even arise this time. Lieutenant Colonel Lippincott of the War Department, who has had a lot to do with the happy sharing of inventions and patents for prosecution of the war, says: "Even we patent attorneys will not suffer in the long run" from the amicable arrangements between inventors and Government that have been worked out."

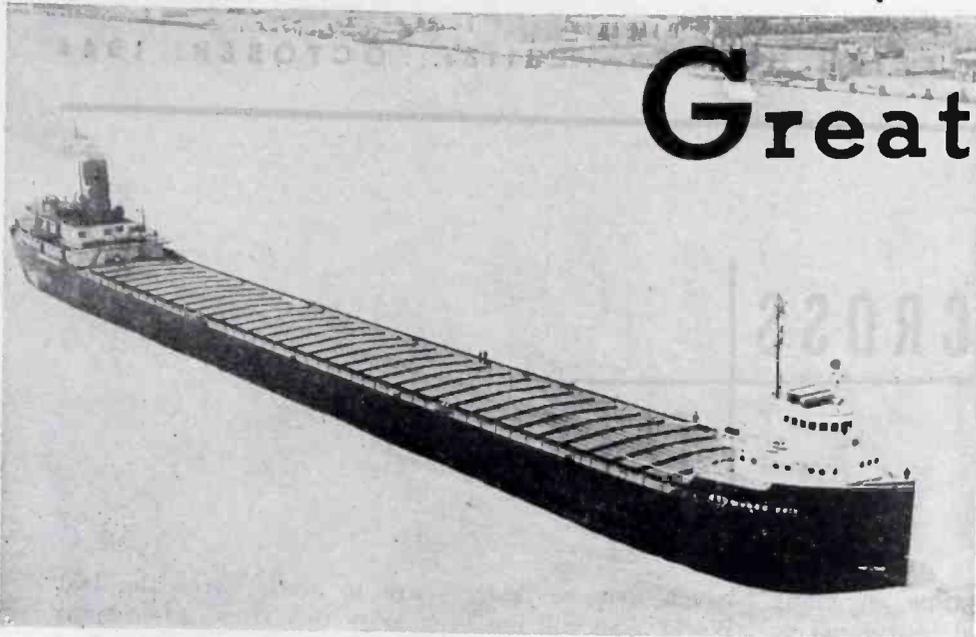
► SYMBOLS . . . To the first engineer who submits an acceptable paper containing circuit diagrams using the ASA component-part symbols printed on page 93 of our July issue the editors of ELECTRONICS offer a free lunch, with all the trimmings. We'll buy it here in New York, adding our own personal charms in the event that the lucky man is in this neck of the woods. Or we'll forward sufficient cash to cover a meal in the ritziest restaurant in his home town.

ELECTRONICS is now using the standard symbols in all circuit diagrams. Converting old symbols to the new ones on every single circuit diagram accompanying every manuscript is a tough, time-consuming job, with possibilities of making errors. The editors don't like this kind of work—thus the free-meal offer!

► SHORT BUT SWEET . . . Following the 50 to 60 pages of featured papers appearing in the average issue of ELECTRONICS there is nearly as much material again in back-of-book "Departments," indexed on the Contents page. Items handled in brief style usually get that way for one good reason or another. For example, perhaps censorship prevents the editors from immediately securing sufficient data to justify a feature article, yet they wish to keep readers as fully informed as circumstances permit. In no sense does departmental handling imply lack of importance. There is no room in our columns these days for unimportant material.

Discerning readers tell us that they frequently pick up just the ideas they need from the following departments: *Industrial Control . . .* covering the use of tubes in industry; *Tubes At Work . . .* devoted to immediately useful communication applications; *Electron Art . . .* discussing laboratory work pointing to applications just around the corner; *New Products . . .* describing commercially available gear; *New Books . . . News of the Industry . . . Backtalk.*

Great Lakes



ships on all of the Great Lakes. Two other shore stations, one at Duluth and one at Port Washington, cover local traffic in their respective areas. In addition to the Lorain-operated shore stations there are stations operated by other companies in the United States and Canada which handle traffic. About 95 percent of the ship installations were, however, made by the Lorain Company.

TO FACILITATE the movement in the Great Lakes of nearly 200 million tons of bulk freight a year by some 600 cargo steamers, the Lorain County Radio Corporation has developed over the past decade a highly efficient radiophone service.

Ships can be routed while underway, thereby completely coordinating dock and rail facilities. As a result, an estimated 2000 freight cars are saved each day. In addition, the system provides ships with instantaneous contact with the outside world in case of emergency.

Regular weather reports are broadcast over the system, and ships can call one another for additional information.

Completely Automatic

Ship personnel require a communication system for the operation of which no training beyond that necessary for an FCC restricted radiotelephone operator's permit is needed. Therefore, the Lorain company has developed a completely automatic dial-controlled installation for use in the area shown in Fig. 1.

The dial phone shown in Fig. 2 can be mounted aboard ship wherever it will be most convenient. Usually one hand set is mounted in the pilot house, and one in the captain's cabin. Lifting the hand set from its cradle puts remote transmitting and receiving equipment into operation.

One of six two-way crystal-controlled channels is selected by dialing. A lock-out feature prevents

dialing the transmitter onto the air on a frequency already in use, except on general calling and ship-to-ship channels. Once the connection is established, conversation is carried on as in usual telephone installations. Voice-operated relays switch the ship's transmitter on and off the air, eliminating the need for a press-to-talk button. At the shore station a voice-controlled relay switches the land line from receiver to transmitter in accordance with the conversation. A noise discriminator prevents operation of the relay by atmospherics.

The main station at Lorain, shown in Fig. 3, is 30 miles west of Cleveland and communicates with

Marine Communication Network

Communication is handled on ship-to-shore frequencies in the 2, 4, 6, and 8 Mc bands; a ship-to-ship channel in the 2 Mc band; and an emergency channel in this latter band. The frequencies used were chosen to give complete coverage on the Great Lakes. Calls are routed over channels which will give the best service at the particular season of year, time of day, and distance to be covered. From the shore stations connection is made to shipping offices, weather bureau and elsewhere over telephone land lines.

Equipment Aboard Ship

The ship equipment comprises a six-frequency crystal-controlled transmitter, six crystal-controlled



FIG. 1—Location of Lorain County Radio Corporation's shore stations in the Great Lakes marine communication network, showing relation to shipping lanes

Ship Radio System

Detailed description of Lorain County Radio Corporation's automatic service employing dial operation, selective ringing, six crystal-controlled two-way channels, relay-operated transmitters, and voice-controlled terminal equipment with noise discrimination

receivers, power supply and control equipment all in a metal cabinet as in Fig. 4, a transmitting and a receiving antenna, and one or more telephone instruments installed at suitable locations on the ship.

The equipment in the cabinet is assembled on sliding chassis, removable for inspection and servicing. Automatic plug-in arrangements complete all connections when the chassis are slid home. Only the connecting wiring and plugs are attached to the cabinet proper, thus providing complete accessibility of equipment and making it possible to install the cabinet with its rear and side faces against bulkheads or lockers. This feature of considerable importance on shipboard.

The equipment is completely sealed. A main power switch at the top of the cabinet disconnects the power or connects an emergency power supply. The cabinet door is equipped with a tumbler lock to protect the equipment against unau-

thorized manipulation. In installations where the antenna lead-in wires can not be placed beyond reach, they are insulated in heavy hose.

The transmitter operates directly into a single-wire antenna 50 to 100 feet long, carried as high as possible. The receiving antenna is usually installed on the opposite side of the ship from the transmitting antenna and is connected to the cabinet through a shielded low-capacity rubber-covered lead-in cable.

The equipment operates from 90-115 volts d.c. (the usual electric power aboard ships). The stand-by demand is approximately three amperes; under full operation the installation draws nine amperes. The 500 volts of plate power for the transmitter are supplied by a dynamotor in the base of cabinet. Filters in the ship's power line and in the dynamotor control-unit absorb interference. A rheostat adjusts the dynamotor for operation at the

ship's average voltage. The receivers, which are in constant operation, operate directly from the ship's power mains, eliminating the need for a continuously-running converter.

Features of Ship Transmitter

The 50-watt ship transmitter consists of a crystal-controlled 6L6G oscillator and a plate-modulated final amplifier with three RK39's in parallel, shown in Fig. 5 and 6. The three tubes in parallel in the final r-f amplifier permit transmission at somewhat reduced power if one tube fails. Frequency stability is within 0.02 percent.

Individual crystals are provided for operation in the 2, 4, and 6 Mc bands; operation in the 8 Mc band is obtained by doubling from the 4 Mc crystal. Selection of the desired frequency is accomplished under control of the remote telephone dial by means of relays. The relays for the final stage use Isolantite supports for the contact members to



FIG. 2—Wall phone. Cradle holds the handset and set securely in heavy weather

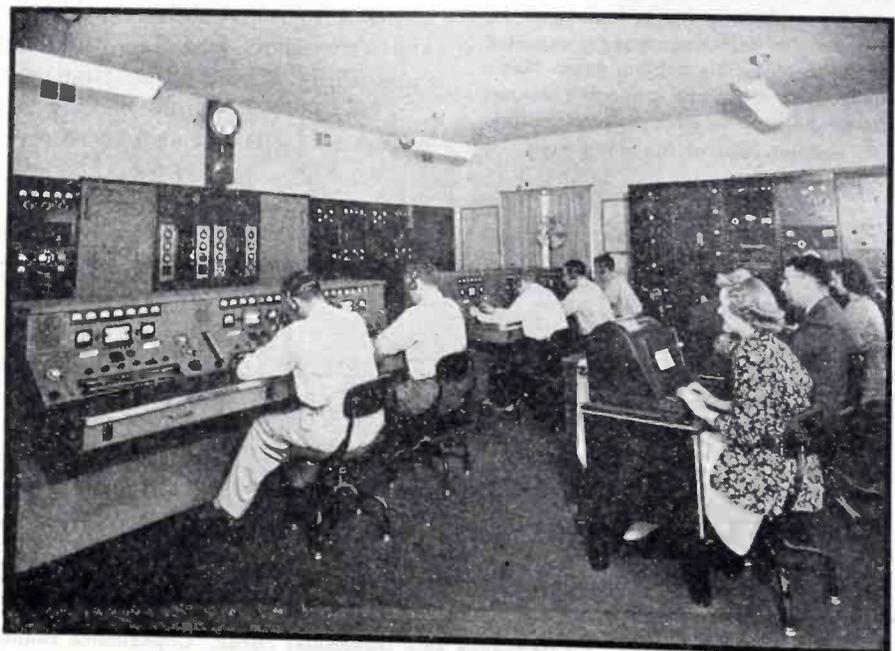


FIG. 3—Main shore station at Lorain on Lake Erie. Each of the six operator positions has push-button selection controlling six transmitters and receivers

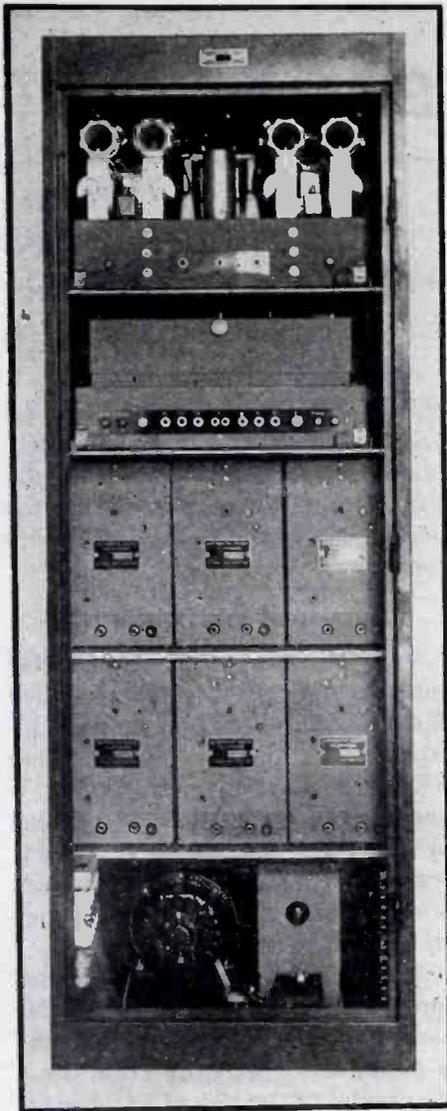


FIG. 4—Ship radio equipment, shown with the front door removed. The six-frequency crystal-controlled transmitter is at the top. Immediately below is the modulator and relay assembly. Occupying most of the space in the cabinet are six receivers. The transmitter voltage is supplied by the dynamotor at the bottom. The selective ringer is mounted on the inside of the cabinet door. Meter jacks, fuse clips and adjusting screws are at the front of each unit to facilitate maintenance of the equipment

reduce losses. Complete shielding is provided between the oscillator and final stages. Capacitance-coupling between oscillator and final reduces the number of tuned circuits which must be switched.

The modulator and audio-frequency stages, together with the control equipment, are mounted on a second chassis, shown in Fig. 7 and 8. Carbon microphones in the hand sets and the two stages of speech amplification provide sufficient power for 100 percent modulation of the carrier. All tubes in the transmitter are heated during standby periods so that the transmitter may be started instantly.

Features of Ship Receivers

Six separate complete and self-contained superheterodyne receivers constitute the receiving system. To insure the frequency stability necessary for permanent tuning, the local oscillator of each receiver is crystal controlled.

The use of six complete receivers insures signal reception on all frequencies, obviating the necessity for switching receiver frequencies as the ship passes from the area served by a shore station on one frequency into that of another. This assurance that calls will be received at all times on any of the frequencies employed is of the utmost importance where the distance range of these different frequencies varies with time of day and season of year. Moreover, separate receivers for each frequency make it possible to receive distress calls on the frequency assigned for such calls while at the same time calls can be received on the working frequencies. Calls can also be received

on other frequencies if one of the receivers should fail.

Operation of Shipboard Equipment

In making a call the ship operator removes the hand set from the cradle, thereby closing the microphone circuit and also starting the dynamotor. To change the ship's equipment over from the normal standby condition to the calling condition the ship operator dials a two digit number. This number determines which of the six available channels will be used for the call. The channel to be used is chosen on the basis of the type of service desired (ship-to-shore or ship-to-ship), the particular shore station being called, and the prevailing atmospheric conditions.

The dial in the telephone unit transmits a number of pulses corresponding to the digit dialed. These pulses actuate a counting-chain relay system. The first digit is recorded by the counting system, which then locks itself so that further dialing will not change this first count. This prepares the transmitter for operation on the particular channel selected.

In addition to locking itself at the end of the first series of dial pulses, corresponding to the first digit of the channel number, the counting system also switches the common outputs of the receivers from the standby loudspeaker in the hand set units, connects them to the hand set ear-phones, and disconnects the plate voltages from all the receivers except the one associated with the dialed channel.

With the proper channel receiver connected to the ear-phones the operator can tell by listening

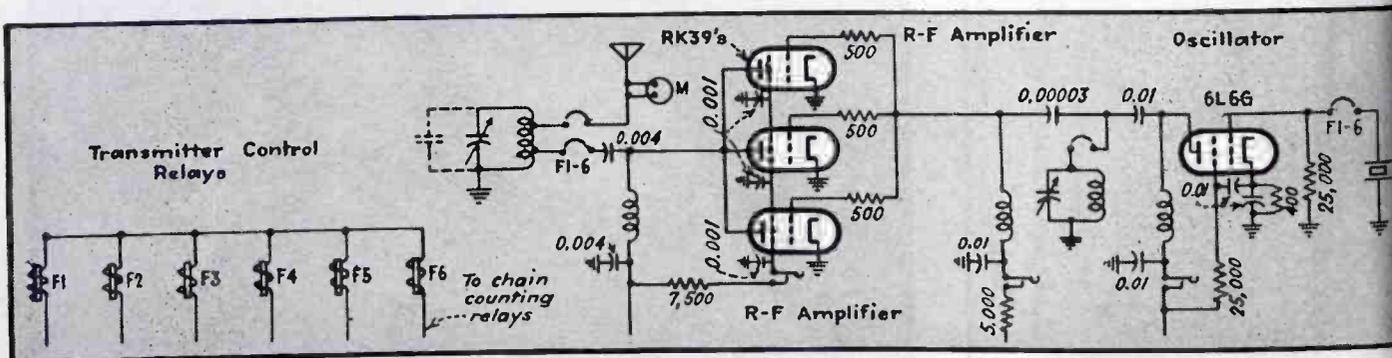


FIG. 5—Six-frequency ship transmitter circuit. Capacitance coupling between oscillator and final reduces the number of tuned circuits which must be switched. The frequency-selector relays are actuated from the chain-counting relays on the modulator chassis

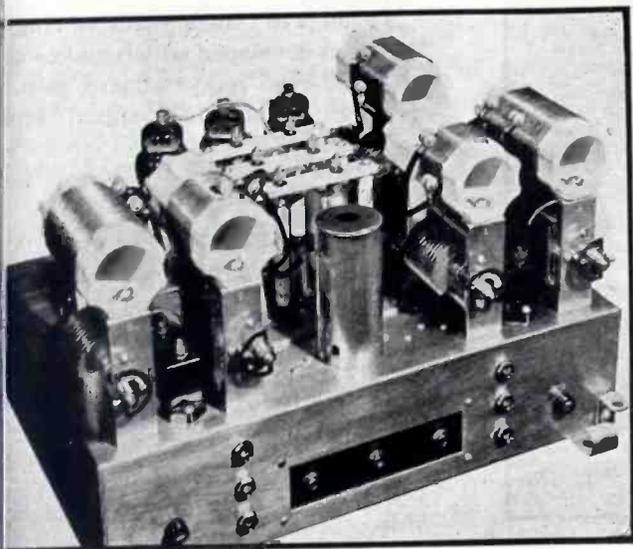


FIG. 6—Ship transmitter chassis with band-changing relays

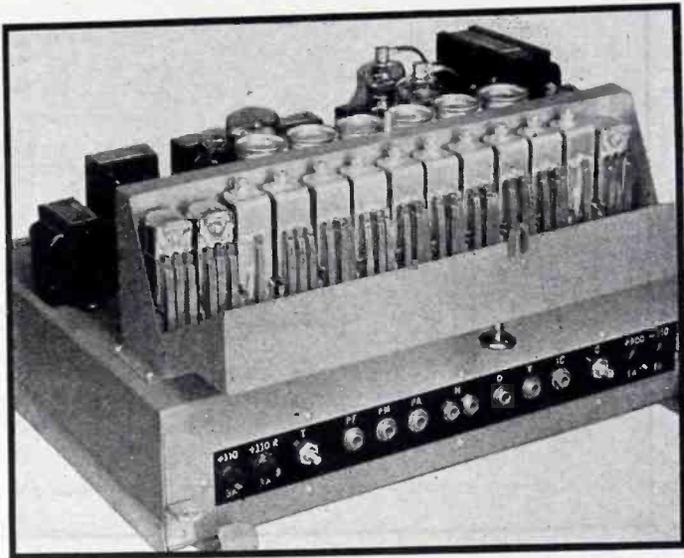


FIG. 7—Modulator and a-f stages, with chain-counting relays

Whether or not that channel is in use. If it is, he hangs up and dials another channel; if it is clear he dials the second digit of the channel number. To prevent putting the transmitter into operation on a busy channel, dialing the second digit of the channel number causes AVC voltage from the receiver to be applied to a 6C6 "carrier-tube" grid. Should the selected receiver receive a radio carrier, the AVC voltage developed thereby and impressed on the carrier tube prevents the flow of plate current through this tube and hence through the transmitter plate voltage relay which is in its plate circuit. The transmitter is thus locked out in the event that the channel dialed is already in use.

If no signal is received, the plate-voltage relay operates, applying plate voltage to the transmitter and closing the circuit to the transmitter channel-selector relay which has already been prepared for operation by the dialing operation of the first digit. The transmitter channel-relay acts, placing the crystal and tuned circuits for the selected channel into the transmitter circuit.

The plate voltage relay has another set of contacts which close to apply screen voltage to the 6L6G first audio tube, putting that tube into operation, and also closing a feedback circuit in this stage which converts it from an amplifier to a 300-cps oscillator to generate an attention tone.

The 300-cps tone operates a slow-release voice-relay through copper-

oxide rectifiers (used to keep the number of tubes whose heaters must be kept hot to a minimum) which relay closes the oscillator plate circuit of the transmitter, and shunts out 2000 ohms in the grid circuits of the modulator and r-f final stages, thereby reducing the grid bias of these tubes and putting the stages into operation. The transmitter goes on the air modulated at 300 cps.

In operating, the voice relay also inserts 25,000 ohms in the plate supply of the selected receiver to prevent its operation during transmission. Although transmission and reception are on slightly different frequencies in a given

channel, the proximity of the ship's transmitting and receiving antennas makes this precaution necessary.

Shortly after the completion of the dialing operation, the feedback circuit in the first audio stage opens. As a result, the slow-release voice-relay takes the transmitter off the air, and returns the receiver to operation.

Speaking into the hand set microphone produces voice signals which, after amplification by the first stage of the audio amplifier, operate the voice relay as did the 300-cps attention tone. The voice relay does not clip words between syllables because of its slow-releas-

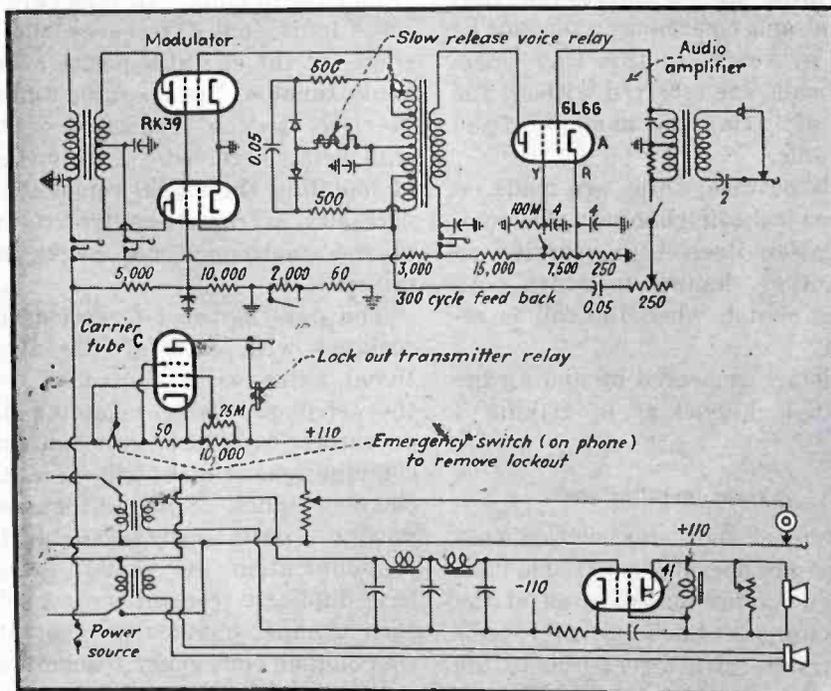


FIG. 8—Ship transmitter modulator circuit and audio amplifier circuits

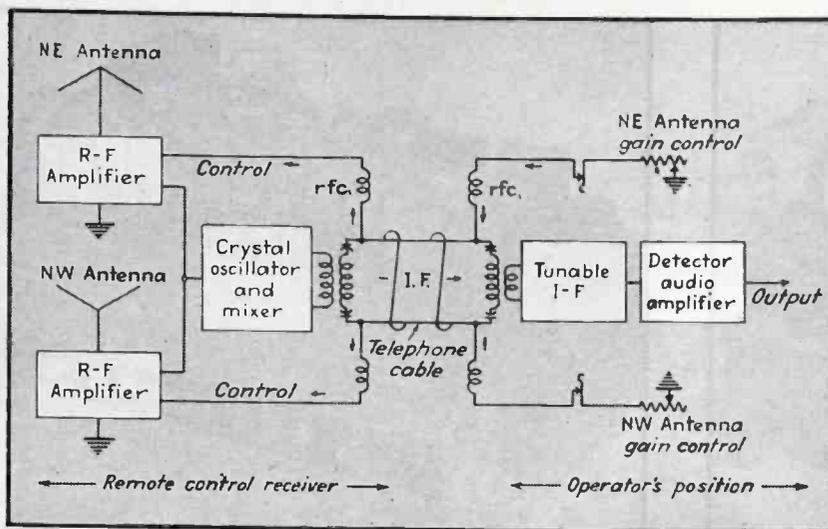


FIG. 9—Block diagram of shore station remote-control receiver.

ing action. When the operator stops speaking, the transmitter is made non-operating, and full voltage is applied to the receiver.

When a call is received aboard ship the signal from the shore station or another ship passes through a low-pass filter whose cut-off is 300 cps, thereby eliminating noise and voice signals from succeeding equipment. In the case of calls from shore stations, selective ringing is employed (as outlined in later paragraphs). The receivers of the channels reserved for shore-to-ship calls have their outputs connected to the selective-ringing equipment through the low pass filter.

The emergency and general-call channel receiver is wired directly to a separate speaker without a low pass filter in its output so that general and emergency calls can be made by voice. In this way emergency calls are received without the delay of lifting the hand set from its cradle.

Calls between ships are made on the general-call channel; the communication itself being carried on on another channel to which both parties switch when the call is received.

Calls are answered by dialing the indicated channel as in making a call.

Shore Installations

A typical shore installation consists of six operator-positions, each position having access to all of the six channels. Each operator position has its own direct line to the nearest long-distance tollboard, from which connection is made to

or from the desired land party.

To eliminate interference from the 500-watt shore station transmitters, the shore receivers are located several miles away in unattended remote-control stations.

Each receiver has two directional antennas, one pointing to the north-east, one to the north-west. Each receiver antenna has its own r-f stage. The r-f stages feed to a common mixer with a crystal controlled oscillator. The resulting i-f is fed over telephone cable pairs to i-f stages at the shore station, as shown in Fig. 9.

Because the transmitter frequencies of different ships vary within the permissible tolerances of the channel, the i-f's developed by the crystal-controlled oscillator differ from ship to ship. To take care of these individual differences, the i-f stages at the operator positions are made tunable, the operator tuning precisely to the frequency of the ship being received. This method of handling the signal removes the necessity of remote-control tuning of the unattended r-f stages and mixers.

The gain of the r-f sections associated with each of the directional antennas is controlled over the telephone cable, enabling the operators to choose the antenna combinations which will give the clearest signal. Since all channels must be continuously available for communication the shore stations have duplicate transmitters, one for each channel handled by that station, and an emergency transmitter.

When calling, the shore station should signal only the ship called.

To achieve this, a selective ringer has been developed which makes use of tuned-reed relays aboard ship to distinguish one call signal from another.

Selective Ringing

The shore station can modulate its carrier at any one of seven frequencies lying between 120 cps and 300 cps by dialing digits one to seven at the operator position. Four reed-relays tuned to four different frequencies in the available seven-frequency series are used in the selective ringer on board each ship.

To call a specific ship the shore station transmits five tone pulses without intervening pauses. This means that successive pulses must be of different frequencies to be distinguished. Also, since there are but four tuned-relays aboard ship, one of the reed frequencies must be repeated. This arrangement gives slightly over 5000 possible combinations, so that 5000 ships may be called.

The shore operator dials the call number of the ship to be reached. At the ship the audio impulses are delivered by the shore-to-ship receiver, through the low-pass filter which prevents operation of the selective circuit by noise or voice, to a type 41 amplifier tube and thence to the selective ringer. If the first pulse is of the frequency to which the first reed-relay is tuned, the relay operates, connecting the receiver to the next relay in the series. The process is repeated as long as the pulses are of the required frequencies to operate the relays. If at any time the frequency is not that of the next reed, the circuit is opened so that the next pulse can not operate a relay. After all five pulses have been properly received, the selective ringer rings a bell at the hand set location.

Voice-Controlled Terminal Relays

Terminal connection to the shore-party land-line is voice-operated and has an anti-noise feature. Several terminal systems have been tried; the present system, developed from these earlier systems, takes two forms, both of which provide the required operating characteristics.

The chief problem in terminat-

the land line arises from the requirement that the land line handle traffic in both directions. This two-way traffic must be divided, the transmission going to the shore transmitter, reception coming from the shore receiver. The transmission loss over the land line is about 1 db, with the result that there is a differential of 30 db between receiver output and transmitter input under the operating conditions which provide the land party with adequate signal strength at the phone receiver.

If the receiver output, transmitter input and land line were paralleled, the shore transmitter would radiate that half of the conversation received from the ship by the shore receiver, as well as that from the shore party. This means that the receiver tuned to the shore transmitter would receive both halves of the conversation.

In addition to this undesirable lack of privacy, and since the ship transmitter is off the air while the shore party is speaking, the shore receiver—which employs AVC—is at its maximum sensitivity when the shore party is talking. Were the direct connection mentioned above used, the noise in the output of the shore receiver would be added to that already present on the land line and fed out over the shore transmitter, with the result that there would be an abnormally high noise-level in the transmission of the shore party.

Both to add to the privacy of the conversation and to reduce the noise in the shore party's transmission, it is desirable to switch the

land line to shore receiver or transmitter as the conversation demands. Since the ship transmitter goes off the air when that party has finished talking, it seemed possible to operate a switching relay from either rectified voice in the shore receiver output or the AVC voltage developed by the receiver in the presence of a signal, either being an indication that the ship party is speaking. However, noise, especially in the summer on the 2 Mc band in the latitude of the Great Lakes, is so severe as to operate a relay so controlled.

To eliminate the effects of noise, a noise-balancing circuit was developed. As shown in Fig. 10, i-f energy from the receiver is converted by means of an AVC oscillator to 55 and 50 kc. Noise in the receiver i-f produces voltages of equal strength at these two frequencies. The two frequencies so produced are rectified and applied in opposition to a d-c amplifier which operates the land-line switching-relay. Regardless of the noise level in the receiver there is no effective voltage applied to the relay amplifier unless a modulated carrier is present. Then the voltage developed in the 55-kc amplifier will increase, unbalancing the system and operating the land-line relay.

As a further precaution to avoid transfer of the land line from the transmitter to the receiver by random carriers crossing the receiver frequency and momentarily interrupting the shore party's transmission, some voice signal from the shore party is amplified and recti-

fied and used to lock the land-line relay to the transmitter position.

The second system in use at present, shown in Fig. 11, is one which (because of its greater simplicity) is displacing the previously described system. It works on the same principle of balancing out two noise-voltages.

In this system one noise-voltage is taken from the superaudible noises present in the receiver; the other is taken from the audible noise voltages. As in the earlier system, these two noise-voltages are balanced, rectified and applied to the d-c amplifier of the land-line switching-relay. When a modulated carrier is present, the audible frequencies predominate, unbalancing the system. If there is no voice-voltage on the land line from which the relay is locked to the transmitter, the presence of a modulated carrier in the receiver switches the line to the shore receiver output.

This automatic ship-radiotelephone system serves the ships of over 30 different companies operating on the Great Lakes. The concentration of shipping in this area, the cooperation of many shipping companies, the spirit of mutual assistance against spring fog and storms on the part of the ship captains, and the absence of international antagonism has made it economically feasible to develop this communication network.

Regular inspection and servicing of the marine equipment, even to the extent of dispatching a serviceman by airplane in case of faulty operation, has assured the reliable operation of the system.—F.R.

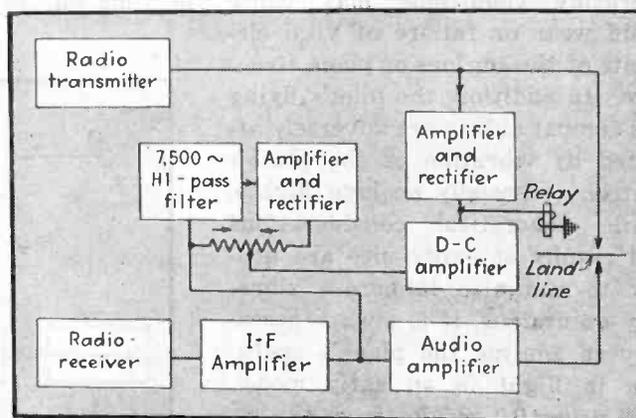
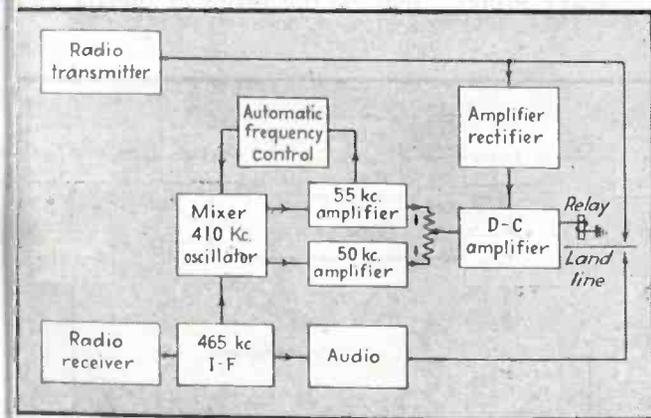


FIG. 10—Frequency-controlled heterodyne oscillator produces two signals, equal in the presence of noise, unequal in the presence of a modulated carrier in this noise-discriminating voice-controlled terminal-relay used in shore stations

FIG. 11—Noise-discriminating voice-controlled terminal-relay using superaudible noise to balance the audible noise. The presence of voice voltages in the receiver's output unbalances the system

Aircraft Vibration Analyzer

Installed in an airplane for tests during flight, this electronic device provides an instantaneous indication and a graphical record of the amplitude of vibration of the power plant, structural members and controls at certain fixed frequencies related to engine speed.

By F. G. MARBLE

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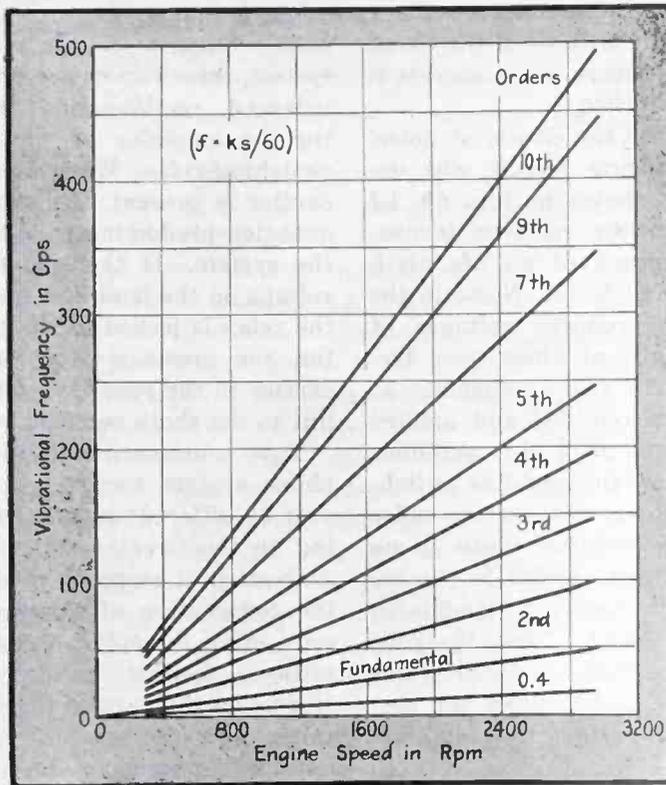


FIG. 1—Curves showing vibration frequency for various "orders" discussed in the text as engine speed varies

ONE important element of aircraft design is the elimination of excessive vibration of the power plant and plane structure during operation. The appearance of excessive vibration at various operating conditions may cause rapid wear or failure of vital elements of the engines or plane structure. In addition, the pilot's flying and combat ability are adversely affected by vibration of the plane's controls, especially on long flights. While theoretical considerations and results of experience are utilized to minimize dangerous vibratory excursions, it is always necessary to analyze the plane's operation in flight in an early model. This necessity results from the incorporation of modifications whose effect cannot be foreseen, such as greater power, higher speeds, lowered weight, new propellers, etc.

Methods of measuring vibrations in planes in flight have been under development for a number of years. Each of these has possessed advantages but all have suffered from the fact that a considerable expenditure of time has been necessary either

during flight or while analyzing the data. In addition, some methods have been liable to errors resulting from the fact that data must be recorded and plotted by an observer. To overcome these defects, general requirements were formulated for an automatic system by the Pratt & Whitney Aircraft Division of the United Aircraft Corp. The automatic vibration analyzer was designed to these requirements by the Bell Telephone Laboratories and manufactured by the Western Electric Co. This analyzer in conjunction with an electrical vibration pickup and a recorder produces a curve of the amplitude of vibratory velocity at a given multiple or order of engine speed versus engine rpm.

Nature of Vibrations

Engineers, in their studies of aircraft vibration, have discovered that for the most part power plant exciting forces originate as a result of one or more of the three following conditions: First, they may be the result of inertia unbal-

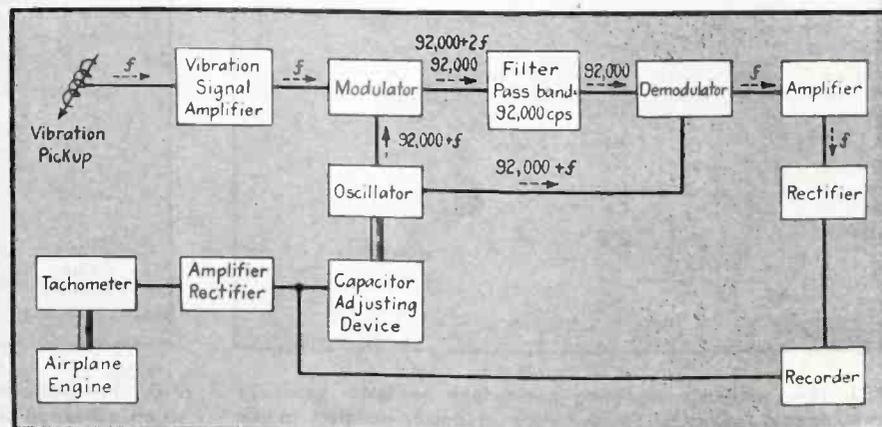


FIG. 2—Block diagram of the analyzer circuit

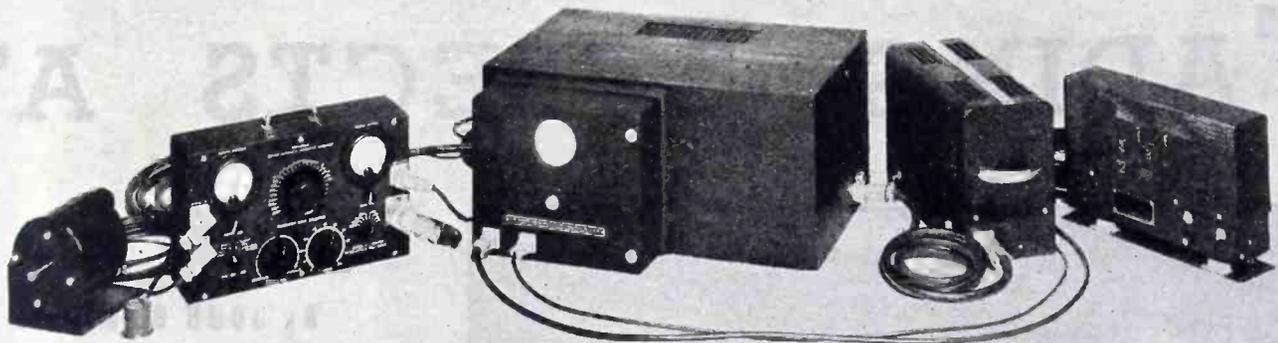


FIG. 3—The test setup, complete except for the recording-pen unit. Left to right: tachometer; control unit for analyzer and recorder; capacitor-drive mechanism and associated amplifier made by the Brown Instrument Co., analyzer power supply and control unit for capacitor drive

ances in the engine or propeller; second, they may result from forces generated by burning gases in the engine cylinders; and third, they may emanate from aerodynamic forces acting on the propeller. Further, they have found that these vibration-exciting forces occur at frequencies corresponding to definite multiples of engine rpm.

To measure and analyze engine vibrations successfully, it is important to obtain the amplitude of vibration at each of several frequencies for each of a number of engine speeds in the operating range of the standard airplane motor. Consequently, twenty-three frequencies expressed in terms of multiples of engine speed, commonly referred to as "orders," were specified for which analyzer tuning would be required. (In addition, it was requested that provisions be made for five subsequent orders to be specified at a later date.) The final selection of orders was based on possible exciting forces resulting from a number of different engine-propeller combinations. These orders are listed in Table I.

Since the speed range of the standard airplane motor is assumed to be between 500 and 3000 rpm (8.33 and 50 rps), the actual frequencies involved cover a range from the lowest of the twenty-three orders at the lowest engine speed to the highest order at the highest engine speed. Thus the frequencies, being definite multiples of engine rps, will range from 3.33 to 500 cps. Because of the difficulty of separat-

FIG. 4—Close-up of the analyzer-recorder control unit



ing the low frequencies, however, the full accuracy of the analyzer is not realized below 5.5 cps.

To illustrate the relation between vibrational frequencies and engine speed, several typical curves are provided in Fig. 1. These curves are plots of the relationship $f = ks/60$ where f is the frequency in cps at which the vibration occurs, s is the motor speed in rpm, and k is one of the 23 pre-selected orders.

TABLE I. ORDERS (Multiples of engine speed)

2/5	8/3
1/2	3/1
9/16	7/2
2/3	4/1
1/1	9/2
6/5	5/1
3/2	11/2
8/5	7/1
27/16	8/1
2/1	9/1
9/4	10/1
5/2	

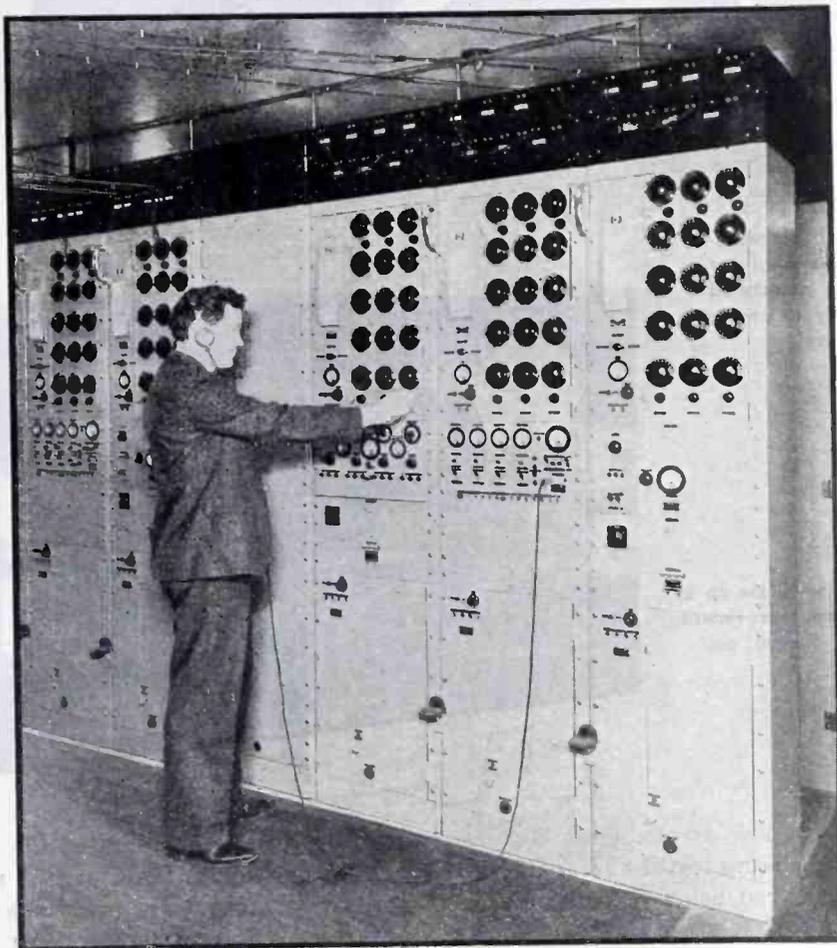
In locating the source of the vibration the key to the source is not the actual frequency at which it occurs but the particular order of vibration, k . Knowing the value of k , the possible sources of the excitation are considerably narrowed down. Although it would be possible to measure the frequency f at which the vibration occurs and determine the engine speed s , then substitute these values in the above equation and solve for k , this is not desirable due to the fact it would require searching for vibration at all frequencies within the band from 3.33 to 500 cps.

Analyzer Circuit Design

The automatic analyzer plots a curve showing the relationship between the amplitude of the vibration and the engine speed for one particular order at a time. The actual frequency of vibration, f , may be readily determined from the previously mentioned frequency equation.

In order to more fully understand
(Continued on page 180)

FADING EFFECTS AT



Racks of receivers used for diversity reception at high frequencies in the RCA receiving station at Riverhead, N. Y.

By JOHN B. MOORE

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to subnormal or abnormal and back to normal—of less than one minute roughly speaking, and generally less than one second. The various types will be identified by their outstanding characteristics and effects.

The simplest case is that in which the carrier and all modulation sidebands vary in intensity simultaneously and in the same proportion. This may be a 20 db drop (10 to 1 in field intensity), or considerably greater. Regardless of the depth to which the signal fades, carrier and sidebands retain their original relative strengths. The signal becomes weak, and may even drop below the noise level, but there is no noticeable distortion.

Theoretically at least, this simple type of fading—in amplitude or depth only—may be caused either by: (1) a change in the reflection or refraction of a single ray by the ionized layer then effective in propagating the signal to the receiving point; or (2) out-of-phase addition, and thereby partial cancellation, of two or more rays arriving over paths of slightly different apparent lengths. Such out-of-phase arrival of two or more rays at the receiving antenna gives rise to a number of different effects.

The interference pattern resulting from the out-of-phase arrival of two or more rays sweeps across any given point at which a receiving antenna may be located. At a given instant, and for any specific and discrete frequency, areas or bands of maximum and minimum field intensity just above the surface of the earth (at an-

THE FIELD STRENGTH of a distant transmitter operating at frequencies between 4 and 24 Mc may vary over a wide range. Diurnal and seasonal variations, and slow shifts with the sunspot cycle, may be largely if not entirely overcome by the proper choice of carrier frequencies. There remains, however, the problem of insuring satisfactory reception during short-period variations, commonly called fading.

This problem is of particular importance to the commercial communications services, including telegraph, printing telegraph, picture transmission and facsimile, telephone and program services. All are adversely affected in one way or another by fading. No single solution for all types of fading and

services has yet been disclosed or put into commercial use.

It is the purpose of this paper to give a coordinated picture of the general problem, the methods of attack employed so far, and the advantages or disadvantages of each method. Violent interruptions or drop-outs lasting from several minutes to several hours or days, caused by terrestrial magnetic disturbances or sun spot activity, will not be dealt with.

Types of Fading

Short-period variations in the signal delivered by the receiving antenna may be of several kinds. The term *fading* will be taken to include any such variation which has a time duration—from normal

HIGH FREQUENCIES

Commercial communications services operating between 4 and 24 Mc are adversely affected by field-strength variations of less than one minute duration. The precise nature of the problem depends upon the type of service. Practical methods of minimizing drop-outs, distortion and errors are reviewed.

tenna height) will occur along the direction of propagation as shown in Fig. 1. Generally, the slower the fading the greater the area covered by any one such maximum or minimum.

The interference pattern also sweeps across the frequency spectrum, the frequency separation between maxima and minima varying greatly. Here again, the slower the fading the more widely separated the maxima and minima.

In view of the statements just made, we may say that slow fading generally covers a large geographical area and a wide band of frequencies.

As the fading becomes more rapid, due to the interference patterns — space and frequency —

sweeping across the surface of the earth and across the frequency spectrum, the areas of maxima and minima apparently become smaller and the separations between frequencies having simultaneous maximum and minimum field strengths also become less. Under such conditions not only are there rapid variations in field strength of all frequencies within a particular band, but also different discrete frequencies, or very narrow bands of frequencies, do not fade in unison. The result is so-called *selective fading*.

Another effect resulting from simultaneous arrival of two or more rays over paths of appreciably different length is encountered when the time-of-arrival of the rays dif-

fers by an amount—measured in milli-seconds—which is appreciable compared to the time of duration of a telegraph dot or of a small element in material being transmitted by radio-photo (facsimile). This is commonly referred to as the *multi-path* effect.

Effects of Fading

The practical effects of the various type of fading shown in Fig. 2 can best be discussed in relation to specific types of radio-communication service. A convenient classification, for this purpose, is:

- (1) Slow-speed telegraphy
- (2) High-speed telegraphy and multiplex
- (3) Radio-photo or facsimile

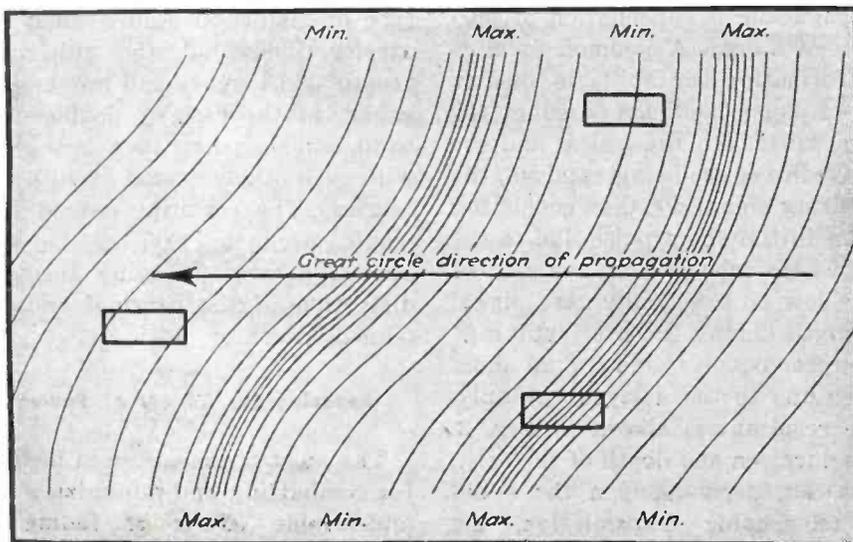


FIG. 1—A typical interference pattern, showing areas of bands of maximum and minimum field intensity. Antennas arranged for space diversity reception are shown as boxes

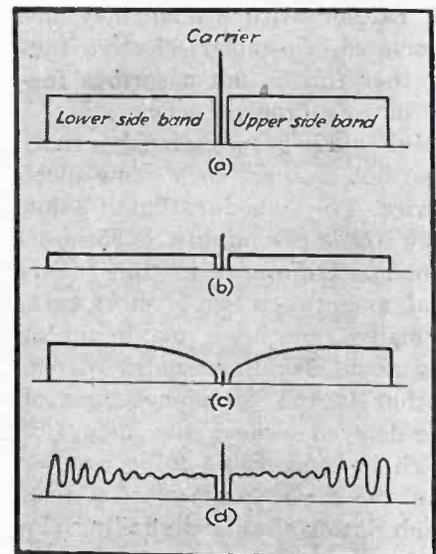


FIG. 2—General types of fading: (a) normal signal; (b) distortionless and non-selective fade; (c) selective fading of a carrier; (d) selective fading of sidebands

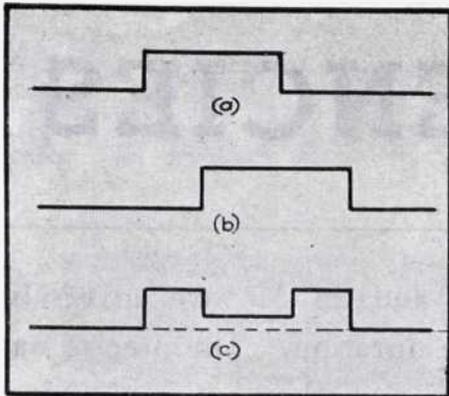


FIG. 3—A "split", showing the effect of multi-path propagation on the formation of a high-speed telegraph dot. (a) The first signal received; (b) the delayed ray signal; (c) the resultant

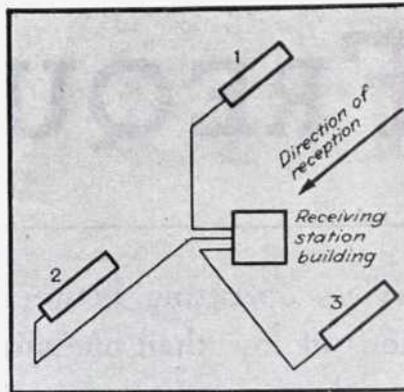


FIG. 4—A space diversity antenna layout. Three directive antennas (shown as rectangles) are placed a number of wavelengths apart, at the corners of an isosceles triangle

(4) Telephone and program services

This classification is based on speeds, or band widths, required.

(1) Slow-speed telegraphy is affected chiefly by the slower type of fading, in which the predominant factor is simultaneous variation of the received field strength of the carrier and all necessary sidebands.

Taking the arbitrary upper limit of 20 dots or square cycles per second for this class of service, and considering that the third harmonic of the fundamental keying frequency is all that is needed for reasonably good envelope formation of the dots and dashes, we see that the total band width involves only 3×20 , or 60 cps. Observation has shown that such sidebands seldom, if ever, fade differently than the carrier with which they are associated. So-called selective fading therefore is not a serious factor in this type of service.

Multi-path propagation normally does not bother such slow-speed service. The time duration of a dot, at 50 words per minute, is 25 milliseconds. Difference in time of arrival, as between two or more rays, normally runs to a maximum of only about 3 milliseconds. An exception is the occasional case of long-delayed echos, the delay of which is comparable to or greater than the time duration of a telegraph dot or similar signalling element.

(2) High-speed telegraphy includes high-speed Morse or printer

operations and multiplex services in which keying speeds may run to 200 dots per second (square cycles per second). At such speed the time duration of a telegraph dot or multiplex keying element amounts to only 2.5 milliseconds.

It will be apparent, from statements made in preceding paragraphs, that multi-path propagation can seriously interfere with such high-speed telegraphic transmissions. A delayed signal, arriving over a longer path, will result in a dot being elongated, the overall effect being to make the mark/space ratio not 50/50 but perhaps as heavy as 90/10 or even 100/0. Satisfactory reception and transcription then becomes extremely difficult or impossible.

Another effect, due to multi-path propagation, is cancellation of portions of a dot. A common form of malformation, or *split*, is due to out-of-phase addition during the time when both the initial and the delayed rays are being received, the resulting signal dot then consisting of an initial short pulse due to the ray which arrived first, a period of very low or practically zero signal strength during the overlapping of the received rays, and a final short pulse due to the delayed ray only. The resultant is shown in Fig. 3. The duration and depth of the split, in a dot, depends upon the speed of telegraphic transmission, the relative amount of delay between rays arriving, and relative phases and amplitudes of the arriving rays.

Selective fading may affect envelope formation when the fundamental and necessary harmonics of the keying frequency run to 200 x 3 or 600 cps or higher. That is, sidebands removed this far from the carrier may, under conditions of extreme selective fading, fade differently than does the carrier, and an originally rectangular envelope shape will suffer malformation.

(3) Radio-photo and facsimile keying speeds and sideband frequencies generally run considerably higher than for high-speed telegraphic service. Roughly, we may set an upper limit of 3000 cps for systems now in use. Such transmissions obviously will be adversely affected by general fading in depth, by multi-path propagation, and by selective fading. The effects, as observed in the recorded picture, may be streaks, widened or elongated elements of the picture subject matter, and loss of detail.

(4) Telephone and program service sidebands require some 3000 or 5000 cps, respectively. General fading, in depth only, reduces the modulation/noise ratio. Depending upon the action of the receiving system and equipment, this may produce a falling and rising level of modulation output (from the loudspeaker) or a rising and falling noise level.

Selective fading produces distortion having characteristics which depend both on the nature of the selective fading and on the type of receiving system and equipment used. One particularly bothersome type of distortion occurs when the carrier fades but the sidebands remain. The upper and lower sidebands, in the case of double-sideband transmission, then beat only with each other instead of with the carrier. The resulting second-harmonic products are, as is well known, a very annoying form of distortion of the original and intended speech or music.

Reducing the Effects of Fading

The most commonly used method for combatting and minimizing the undesirable effects of fading is automatic gain control (agc), known in some types of equipment as automatic volume control (avc).

s method maintains a reasonable constant reference level for speech or music modulation. It is effective against the slower, general fading in which the carrier and sidebands fade essentially in unison and in the same proportion. If the age system is designed to fade too rapidly, it will follow the carrier modulation frequencies and usually, to a considerable degree, remove these modulation components from the final output signal delivered to a loud speaker or other reproduction device or circuit. This action is sometimes referred to as demodulation of the carrier. (This use of the term *demodulation* should not be confused with final rectification, or detection, to which the term demodulation often and unfortunately is applied.)

Automatic gain control to take care of general fading of the slower type, is usually used in combination with other methods that are described in following sections. For convenience, these methods are listed here:

- Frequency diversity
- Space diversity
- Polarization diversity
- Ray selection and diversity
- Limiting
- Frequency and phase modulation
- Exalted-carrier receivers
- Single-side-band.

These general methods will be taken up, separately, in following sections.

Frequency Diversity

This general method derives its name from the diversity, or difference, of fading that often exists on frequencies which may be separated by as little as 500 cps or less. While the basic principle has rather wide possibilities, its practical application has, for various reasons, been pretty much limited to telegraphic services in which the transmission of intelligence is accomplished by keying an r-f carrier on and off. The simplest and probably most widely used system or method is as its purpose the improvement of radio-telegraphic communication without resort to elaborate and expensive receiving systems and equipment. This particular method

will be described, by way of illustration.

In the radio transmitter, the carrier frequency is varied or modulated in any manner which will produce sidebands extending roughly 1 kc each side of the carrier. A common method of accomplishing this is to phase-modulate the master oscillator by means of a tone frequency in the neighborhood of 600 cps. The resulting distribution of energy, in sideband frequencies on each side of the carrier, is determined by the degree of modulation. A limited number of sidebands, spaced 600 cps, is a practical compromise between the wide separation desirable for obtaining the maximum benefits of diversity of fading on the one hand, and the disadvantages of interference to signals on adjacent channels on the other. However, distribution of the total available power between the carrier and a large number of discrete sideband frequencies means less power, and therefore less field intensity, on any one frequency.

Rapid fading which would show or split characters, in the case of a pure c-w carrier, also manifests itself as selective fading which sweeps across the frequency spec-

trum. At the receiving station, therefore, the adverse effects of such fading are minimized by the employment of frequency diversity—the reception of a number of separate frequencies instead of a pure carrier.

Space Diversity

This system makes use of the diversity of fading existing at geographically separated points, specifically at receiving antennas which are spaced a number of wavelengths from one another. Due to the fact that the system does not depend upon or require any special type of signal, but may be used for reception of all types of high-frequency signals and services, it has been widely adopted.

Three antennas generally are used, as shown in Fig. 4. They may be of any type, directional or not, and are placed at the corners of an isosceles triangle. The exact shape and orientation of this base triangle with respect to the desired direction of reception is not critical.

Generally speaking, spacing between the several antennas should be greater for use at the lower frequencies than at the higher fre-

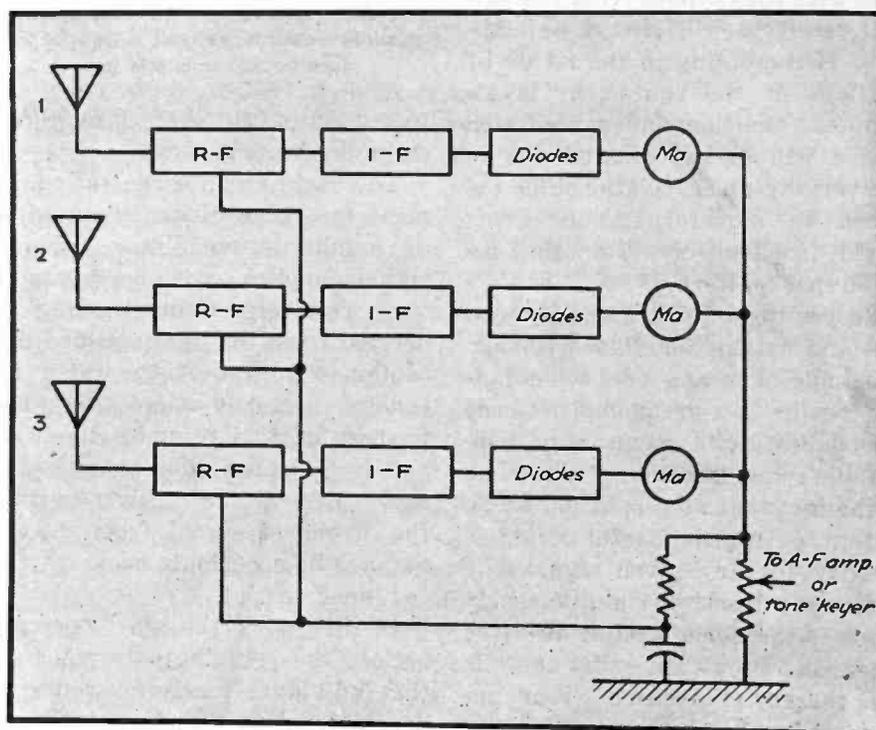


FIG. 5—In this space diversity reception system the rectified output of three receivers is combined, operating the keyer and also supplying bias for automatic gain control

quencies for good diversity performance. A figure of about ten wavelengths or a compromise of about 1000 feet is generally to be recommended, although diversity of fading can be observed between antennas spaced much less than this. However, the greater the spacing, the slower the fading on which diversity action can be expected to be obtained.

In such systems a transmission line of a type having low inherent pickup conducts the r-f signal voltages from each antenna to a separate receiver. The outputs from these three receivers then are either combined or switched, the object being to insure that the utilized output signal will at any and every instant be derived either wholly or chiefly from the antenna at which the best signal-to-noise ratio exists at that instant.

In telegraph service, and others that similarly employ on-off keying of the carrier, general practice is to combine the rectified outputs from the final detectors of the several receivers. This combined, rectified output controls a keying tube or tubes and also supplies bias voltage for automatic gain control as shown in Fig. 5. The purpose of combining after final rectification is to insure that the outputs from the several receivers will always be additive. If combining in the r-f or i-f portions of the equipment is attempted, addition and cancellation effects will be experienced due to the varying phase relationships between the several signals. This would, in effect, create another interference pattern.

Proper use of this diversity system and action, together with agc to handle slow and area-wide fading, results in a great improvement in reliability and accuracy of telegraphic communication. This is due to the fact that at practically every instant, during the useful period of the day for any given signal, the field strength seldom simultaneously drops to the noise level at all three antennas. Drop-outs, splits and fills are thereby prevented from appearing in the final output signal delivered by the system and equipment.

In telephone and program serv-

ices, and in others which employ variable depth of amplitude modulation rather than on-off keying, application and use of the space diversity principle is attended by certain complications not met in the case of telegraph service. This is due to the fact that the audio-frequency modulation envelopes of the several signals, delivered by the separate antennas and their receivers, vary in phase. That is, their phases vary with relation to each other as the field-interference pattern sweeps across the antenna locations. Combining two or more such rectified, modulated outputs of approximately equal strengths but out of phase results in a dis-

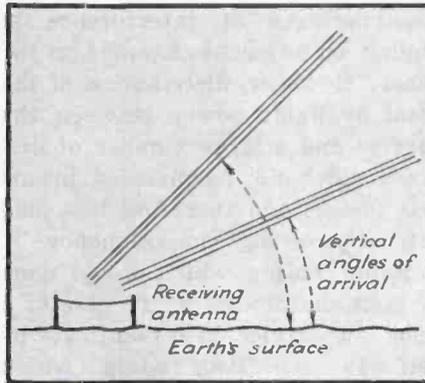


FIG. 6—"Bundles" or groups of rays frequently arrive at the receiving point at different angles. Antenna systems having variable vertical selectivity reduce trouble from this source

torted output if the phase differences are very great.

The usual arrangement of equipment for space diversity reception of amplitude modulated (phone) signals, applies a common agc to all three receivers. Control voltage is derived from the final rectified and combined output of the three receivers normally employed. The purpose of this common agc voltage is to insure that at each and every moment the receiver getting the strongest signal from its antenna will contribute most to the combined output.

If this were the only selecting action, the contributions made by the individual receivers would be proportional to their input signals received, at the moment, from their respective antennas. Actually, however, there is also a considerable

degree of inherent switching action caused by operation of the final diodes of the several receivers into their common load circuit in which the combining of outputs is accomplished. This action is to completely cut off the output or contribution from the diodes of one or two receivers when the output from another rises appreciably above them. As a result of the common agc, and also of the diode action described, a ratio of antenna voltages of as little as two to one (or less) may result in the entire output signal, in the combining circuit, being supplied by the one receiver momentarily having the strongest antenna signal.

The result of this switching action is that distortion occurs only at those instants when the signal delivered by one antenna is increasing in strength and that delivered by another antenna is decreasing in strength and the two momentarily are about equal in amplitude but differ in phase. This effect is minimized by reducing the value of the differential, between the two signals, required to effectively switch; that is, by cutting off the weaker and permitting the stronger to contribute the entire output current present in the combining circuit. Reduction of the required differential results in more rapid switching, and thereby reduces the time duration of the distortion that is experienced.

Proper use of space diversity action, together with agc, insures the best possible signal-to-noise ratio at every instant, and maintains that ratio at a more nearly constant value than is possible by the use of a single receiver. On very rapid fading, which may also be quite deep, the second and third receivers fill in during those very brief but rapidly occurring instants when the signal from the first antenna is practically zero.

Polarization Diversity

Where space is not available for the erection of antennas separated by some hundreds of feet, use can be made of polarization diversity reception. The fact that the polarization of a received wave does not remain constant, but varies

from horizontal to vertical and to other skew angles, makes it possible to obtain the benefits of diversity of fading by using one horizontal doublet and one vertical doublet (or other type antenna), both antennas being located at the same spot. Two separate receivers are used, in the same manner as for space diversity reception. The improvement to be expected is, however, considerably less.

Ray Selection and Diversity

As has been pointed out, long-distance propagation of high-frequency signals does not take place over but a single path at any given instant. Angle of incidence of two or more rays, or bundles of rays, can be observed and measured, as shown in Fig. 6. By selecting only one of these rays, or small bundles of rays, the effects of ray interference can be greatly reduced.

The so-called *Musa* (multiple-unit steerable antenna) system, developed by the Bell Telephone Laboratories, accomplishes this. The antenna system and its associated equipment are designed to effectively pick out any one ray, or small bundle of rays, by means of extremely sharp vertical directivity which can be adjusted to the desired angle. When it is thus possible to pick out only a single ray, the field-interference pattern previously discussed is no longer such a source of trouble. Large variations in the vertical angle of arrival must, of course, be followed by adjustment of the vertical directivity of the system. Where the signal is arriving simultaneously over two paths that differ sufficiently in their vertical angle of arrival, each can be selected separately and the two combined or switched for obtaining what may be termed ray diversity or path diversity.

A detailed description of the antenna system, and of the receiving equipment, is given in a reference cited at the end of this paper. Briefly, the antenna system consists of some twelve separate antennas of the rhombic type, erected in a straight line pointing in the direction of the desired reception. Rather elaborate provisions are made in the receiving building for properly phasing

the signals received from the separate antennas. Adjustment of this phasing is the means employed to produce the sharply directive and adjustable vertical pattern desired.

Limiting

Limiting, by means of non-linear circuit elements such as biased or over-driven vacuum tubes, has relatively little value as a means of reducing the effects of fading except when used in combination with other methods.

In receivers used for telegraph service, employing on-off keying of the carrier, limiting may be used to handle small variations still remaining after the use of agc and

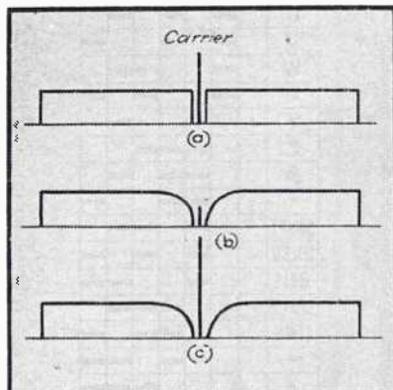


FIG. 7—Principle of exalted carrier receiving system. (a) normal signal; (b) selective fade of carrier; (c) carrier exalted or reinforced at the receiver

diversity reception of any type. Care must be taken, however, not to depend on limiting to such an extent that preceding stages of amplification and frequency conversion are overloaded. If this is not guarded against, various types of spurious interference are apt to be experienced.

In the reception of signals employing variable depth of amplitude modulation, such as telephone signals, limiting obviously can not be used.

In systems employing frequency or phase modulation rather than variable depth of amplitude modulation, limiting is used to eliminate or minimize amplitude variations still existing after the use of agc.

Frequency or Phase Modulation

The use of frequency, or phase modulation as a means of reducing

the effects of fading has as its purpose the elimination of amplitude variations in the received r-f signal. Since intelligence is transmitted by varying the frequency or phase, and not the amplitude, it is obvious that limiting can be made use of in the receiving equipment. Some of the variations still existing after the use of agc can thus be eliminated.

Selective fading, due to its random effects on the numerous sidebands that make up a frequency or phase-modulated signal, results in rather serious distortion of modulation such as speech or music. The system therefore does not improve reception which is bothered primarily by selective fading.

It is of interest to note, in dealing with frequency modulation and phase modulation, that certain conditions of propagation partially convert these types of modulation into amplitude variations. One very annoying manifestation of this is the conversion of frequency or phase modulation at power-supply frequencies (hum) into what is effectively amplitude modulation of the received signal. This results in a rising and falling hum level in the a-f output of the receiver. This resultant level of hum may be considerably higher than that measured at the transmitter.

Radio-photo or facsimile services nowadays use some form of frequency modulation almost exclusively. This is applied either to the r-f carrier or to a tone-frequency sub-carrier which then is used to modulate the r-f carrier of a telephone-type transmitter employing any desired system—amplitude, frequency or phase—for modulating its r-f carrier. Advantages of this application lie in the fact that limiting may be applied, in the radio receiving equipment in one case and in the radio-photo terminal equipment in the other case, to eliminate streaks caused by amplitude fading.

The frequency-modulated sub-carrier system permits the use of standard phone transmitters and receivers.

Frequency or phase modulation of the r-f carrier itself simplifies the modulation problem in the transmitter, particularly in those

cases in which a given transmitter must be used for either telegraph or telephone services, or their equivalents, on short notice. It also, however, complicates the design of the receiving equipment.

Exalted-Carrier Receivers

Selective fading often reduces the amplitude of the carrier, yet at the same time leaves most of the sidebands at their normal amplitudes. The result is second-harmonic distortion due to the absence of a carrier and the resultant beating of one set of sidebands against the other. The exalted-carrier type of receiver prevents this sort of distortion, by maintaining the carrier at a high level at all times as shown in Fig. 7. Carrier voltage at the final rectifier or detector is maintained at such a high level that the effective percentage of modulation can not exceed 100 percent. Actually, the figure is more like 50 percent or even 30 percent maximum.

In general, two different methods may be employed for obtaining the desired result. In one, the frequency of a local oscillator is automatically held to within plus or minus a few cps, or less, of the frequency of the incoming carrier signal. In the other general method, the incoming signal itself supplies the required carrier which is filtered, amplified, and then re-combined with the sidebands. The same net result may be obtained by the use of a sharply selective i-f system which emphasizes or exalts the carrier and at the same time uniformly reduces the relative amplitude of all sidebands.

The use of a single receiver of this type for reception of amplitude modulated phone signals results in virtually complete elimination of the second-harmonic distortion that otherwise is caused by selective fading of the carrier. To take care of the slower, general fading, it is necessary to supplement the exalted-carrier method with some other system such as space-diversity reception.

Single-side-band System

Complete suppression or elimination of one set of sidebands (upper or lower) and partial suppression

	1	2	3	4	5	6	7
A	—	—	—	—	—	—	—
B	—	—	—	—	—	—	—
C	—	—	—	—	—	—	—
D	—	—	—	—	—	—	—
E	—	—	—	—	—	—	—
F	—	—	—	—	—	—	—
G	—	—	—	—	—	—	—
H	—	—	—	—	—	—	—
I	—	—	—	—	—	—	—
J	—	—	—	—	—	—	—
K	—	—	—	—	—	—	—
L	—	—	—	—	—	—	—
M	—	—	—	—	—	—	—
N	—	—	—	—	—	—	—
O	—	—	—	—	—	—	—
P	—	—	—	—	—	—	—
Q	—	—	—	—	—	—	—
R	—	—	—	—	—	—	—
S	—	—	—	—	—	—	—
T	—	—	—	—	—	—	—
U	—	—	—	—	—	—	—
V	—	—	—	—	—	—	—
W	—	—	—	—	—	—	—
X	—	—	—	—	—	—	—
Y	—	—	—	—	—	—	—
Z	—	—	—	—	—	—	—
&	—	—	—	—	—	—	—
.	—	—	—	—	—	—	—
SHIFT	—	—	—	—	—	—	—
UNSH	—	—	—	—	—	—	—
BELL	—	—	—	—	—	—	—
SPACE	—	—	—	—	—	—	—
LINE	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
/	—	—	—	—	—	—	—

FIG. 8—Seven-unit telegraph code used to prevent printing of wrong letters due signal malformation

of the transmitted carrier, as employed in some phone services, is not intended primarily for reduction of fading effects. Since the system necessarily employs an exalted-carrier receiver, however, it gives the improvement described above.

Special Code Systems

In view of the apparent impossibility of completely overcoming all types of fading at all times, the problem of providing reliable telegraphic communication has been attacked from another angle. This is to develop a code or system of communication which will tolerate any reasonable malformation of the signal, yet which will not cause an incorrect letter or character to be recorded on the received copy.

This attack has been primarily aimed at development of printing telegraph services. The so-called 5-unit code, for printer service, is so constituted and arranged that the dropping out of one or more impulses (marking bauds) by fading, or the accidental filling-in of spaces by static or interference, will result in the printing of an incorrect letter or character. To prevent such errors, or *transpositions*, there has been developed a code and system which will print a special error indicator sign when the incoming signal has suffered mutilation.

A printing-telegraph code in which each selecting combination consists of only three marking elements, out of a total of seven available per character, provides the required performance. This code is shown in Fig. 8. If either fewer or more than three marking or selecting impulses are received, the receiving machine prints the special error indicator sign. Fading can not, therefore, result in errors or transpositions,—only the special error indicator sign being recorded in such cases.

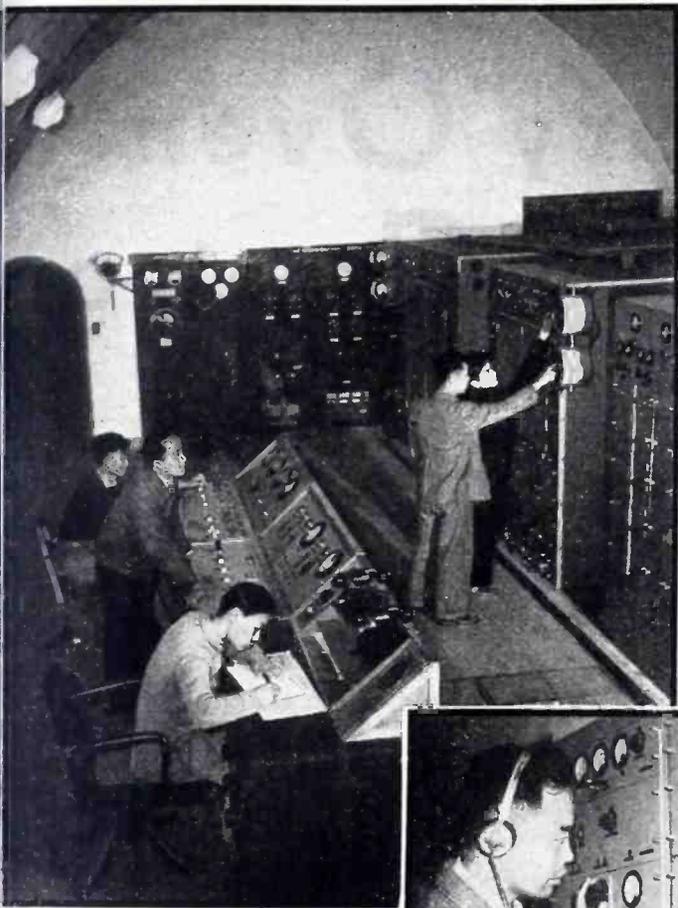
Summary

It is apparent, from the data given in the preceding sections, that no one method constitutes a complete solution to the problem of fading and its undesirable effects on signals. It also will be apparent that different combinations of the basic methods must be used for different types of service. The particular combination best suited to any given service and circuit depends upon the type and quality of service required and also upon the total cost justified by the business to be handled.

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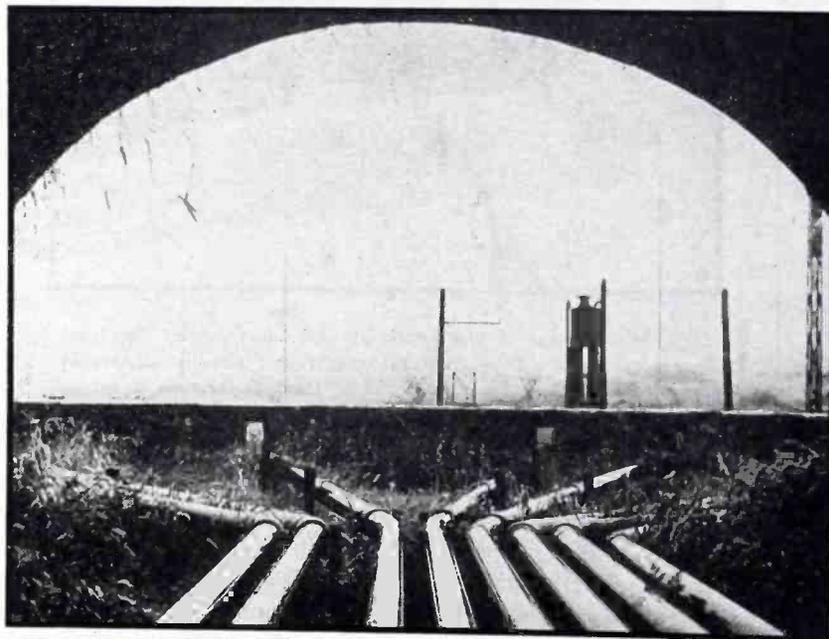
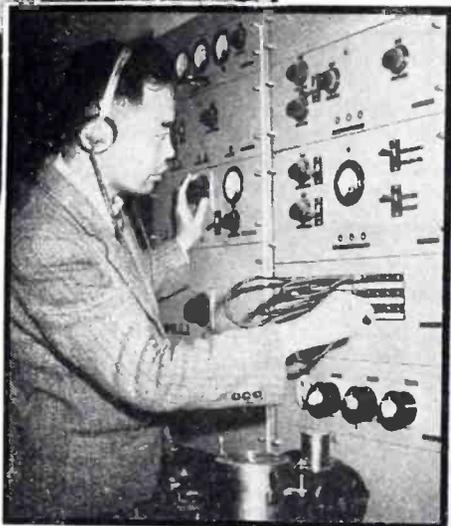
This is XGOY



LEFT—Manned by Chinese technicians and located in a deep cavern at Chungking, this Marconi-built transmitting equipment carries the voice of free China to the world. Even direct bomb hits by the Japs have not been able to put it off the air

BELOW, RIGHT—Director of XGOY is Professor Feng Chien, authority on electro-magnetic waves and dean of the college of engineering of the University of Chungking. His training includes time with General Electric Co. at Schenectady and with German AEG

RIGHT—Speech-input tests are made by Wang Shan-wei, engineer in charge of the transmitter operated by the International Broadcasting Administration. American reception of the station's signal goes to networks through the ham rig of Charles E. Stuart



Power source for the Chungking transmitter is practically spoon-fed to keep within skimpy ration of coal. Power is too undependable for functional apparatus and is used mainly for lights

Beam antennas at XGOY are powered through this series of coaxial cables emerging through cave mouth. American troops in China depend on the station for entertainment and news of home. Other broadcasts are in Burmese, Russian, Dutch, Spanish, Japanese, and Mandarin, each beamed to the appropriate area

Laboratory Oven Temperature Control

Rise and fall of the mercury column in an oven thermometer tunes and detunes a high frequency oscillator. The resulting variation in oscillator plate current operates relay which turn oven heater current on and off

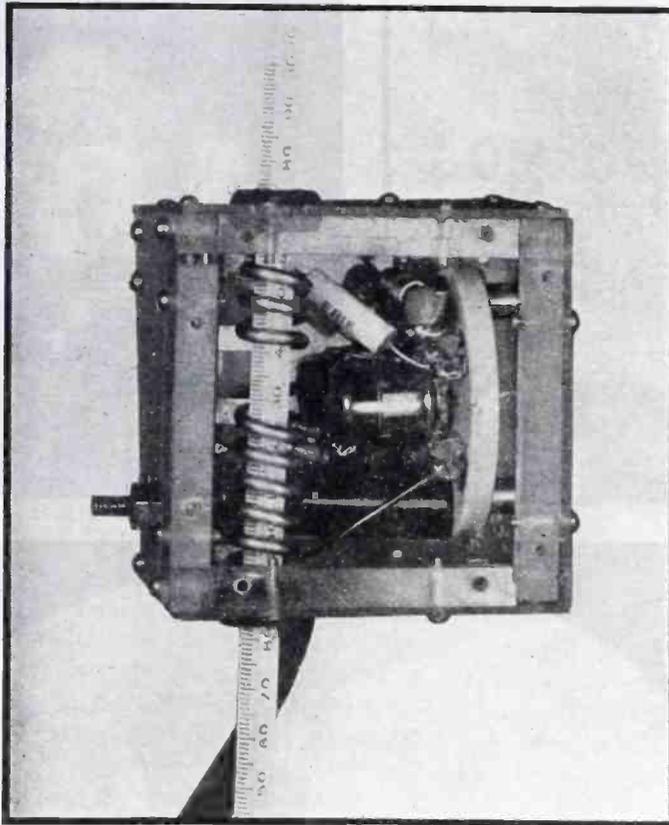


FIG. 2—Close-up of the oscillator unit, shown with the front cover removed. It is light in weight and readily supported by the thermometer which passes through it

THE TEMPERATURE of laboratory ovens may be automatically maintained within ± 0.5 deg C by means of the electronic control to be described, the precise accuracy being dependent upon the character of the thermometer used to indicate oven temperature.

The control may also be used as a

safety device to cut off heater current in the event that standard controls supplied with stock ovens fail. In this case it is adjusted to operate at a temperature slightly higher than the critical value and takes over control of heater current at that point.

Referring to Fig. 1, it will be

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seen that the control is built in two separate units, connected together by means of a flexible cable.

Description of Circuit

The oscillator unit, which operates at a non-critical high frequency, is designed around a type 955 "acorn" triode tube and is contained in a plastic case measuring $2\frac{1}{2} \times 2\frac{1}{2} \times 2\frac{1}{2}$ in. It is constructed in such a manner that the exposed end of the oven thermometer may pass through the tank coil. Tight rubber grommets hold the unit in place on the thermometer at any position along its length, as shown in Fig. 2. Rise and fall of the column of mercury in the thermometer tunes and detunes the oscillator, altering its plate current.

The other unit contains the power supply and control relays, and is contained within a metal cabinet. The two units may be seen on top of the typical oven pictured in Fig. 3.

Adjustment and Operation

To place the electronic control in operation the power supply unit is connected to the 110-v a-c line and the oven input control leads inserted in the plug on the side of this unit. The oscillator unit is then slid

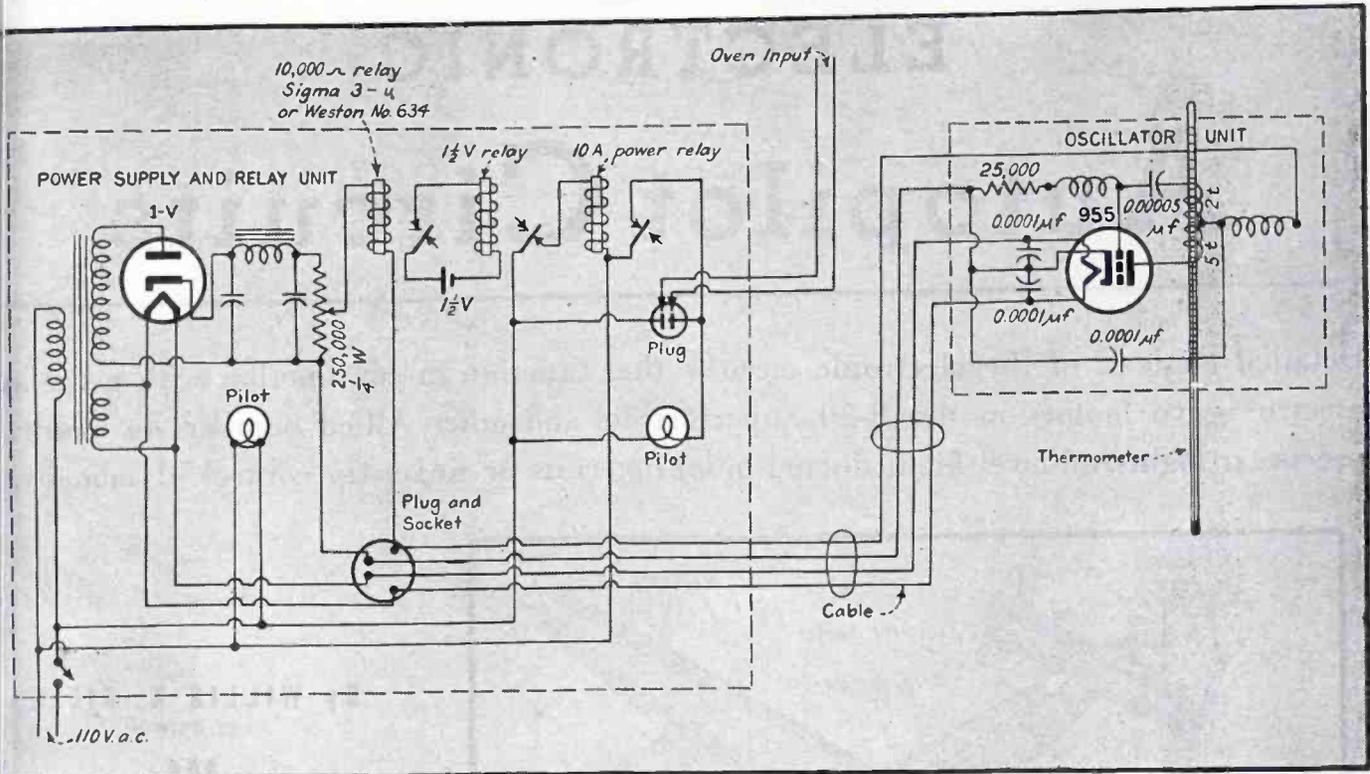


FIG. 1—Circuit diagram of the electronic control device. It is readily constructed from parts available in most laboratories and is relatively simple to adjust

er the oven thermometer and oriented so that the mercury column level with the plate end of the tank coil at the desired oven operating temperature. Oscillator plate voltage is then adjusted by means of the 250,000-ohm potentiometer that the 10,000-ohm plate circuit relay just barely closes. Voltage is reduced and the relay opens.

Increase in oven temperature above the desired value causes the mercury column in the thermometer to rise. Inasmuch as the mercury column rises inside the oscillator tank coil the oscillator is detuned, its plate current rises and the plate circuit relay closes. Closing of the plate circuit relay energizes the 1/2-v battery-operated relay, opening its contacts. The 10-ampere power relay is de-energized and oven current is cut off. Oven current remains cut off until the mercury column falls to the critical value, at which time inverse relay operation takes place and heater current is restored.

Satisfactory action of the electronic control is largely dependent upon the adjustment of the 10,000-ohm relay. The limiting factors with respect to speed as well as accuracy are, however, the characteristics of the thermometer.

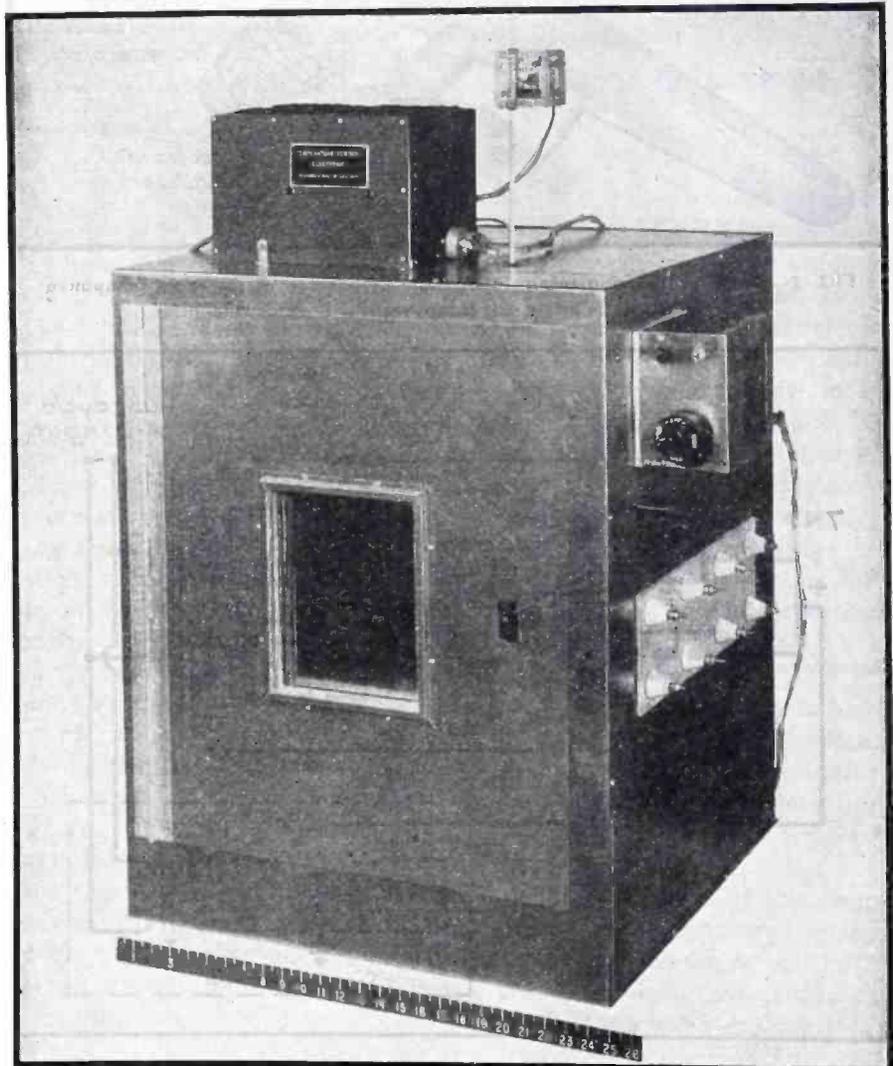


FIG. 3—A typical laboratory oven, showing the two-unit electronic control in position on the top, operating in this instance as a safety control supplementing standard controls

ELECTRONIC Autopilot Circuits

Detailed analysis of the electronic circuits that function in conjunction with gyros and electric servo motors in the B-29 Superfortress and other Allied bombers to maintain precise straight-and-level flight during bombing runs or finger-tip control of maneuver

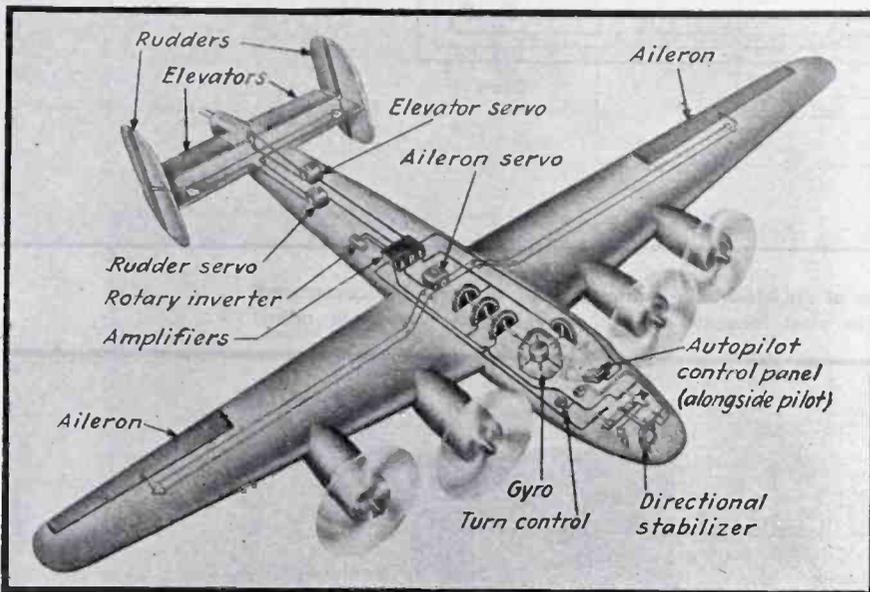


FIG. 1—Drawing showing interrelation but not position of the main component units in the Minneapolis-Honeywell C-1 automatic pilot

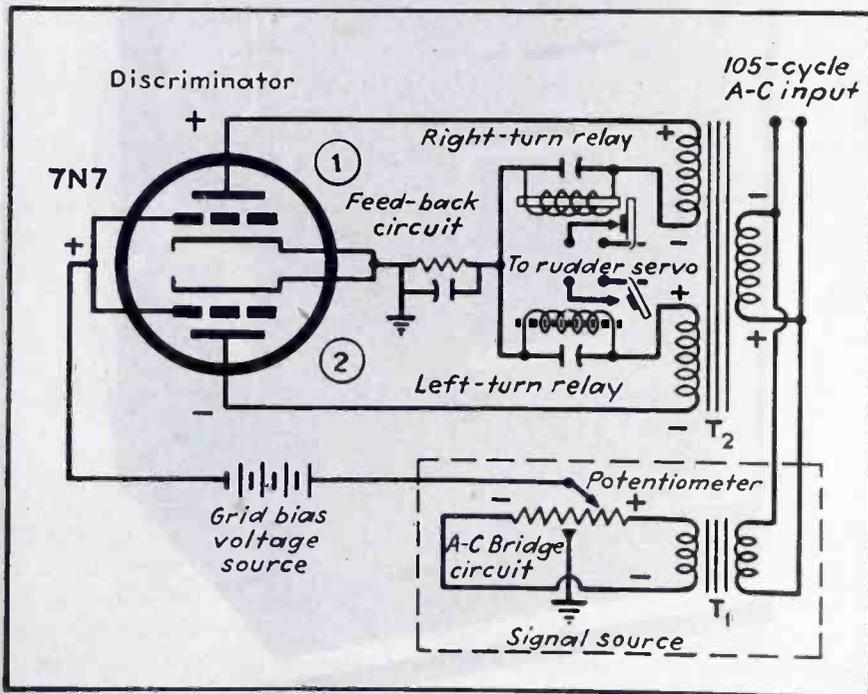


FIG. 2—Simplified schematic diagram of the discriminator circuit used in a single channel of the autopilot amplifier. Two signals, differing in phase by 180 degrees, may enter this stage from the a-c bridge circuit; one makes the right-turn relay operate, and the other makes the left-turn relay operate

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and

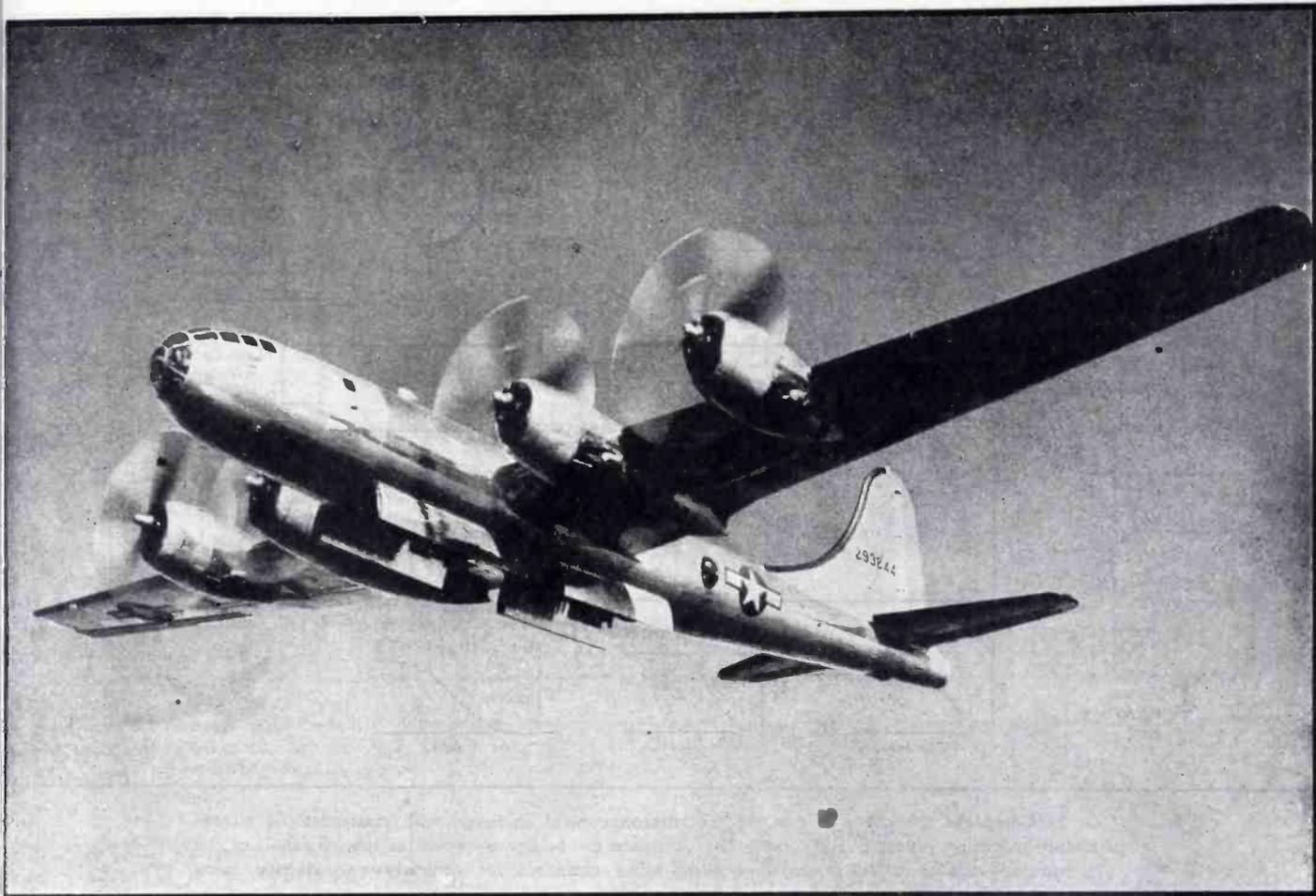
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DURING the few seconds of a high-altitude precision bombing run, an airplane must not deviate appreciably in any direction from its set course. To provide a stable platform for such operations, the Minneapolis-Honeywell C-1 electronic automatic pilot is standard equipment on many AAF bombers, including Fortresses, Liberators and the new Boeing B-29 Superfortress.

The electronic control of the autopilot, developed by company engineers cooperating with the Materiel Command at Wright Field, is standard equipment on many AAF bombers, including Fortresses, Liberators and the new Boeing B-29 Superfortress.

The autopilot works in much the same way as a human pilot. Gyroscopes act as the eyes and the electronic amplifier as the brain of the autopilot in detecting flight deviations. Potentiometers in the gyro housings respond to these deviations and transmit appropriate signals to amplifiers that control the operation of servo units, which are special electric motors that act di-



The C-1 electronic autopilot is used on the Boeing B-29 Superfortress

rectly on the control cables of the airplane.

The precision of even the most skillful human pilot is limited by such factors as his reaction time, susceptibility to fatigue, inability to detect slight variations the instant they occur, errors in judgment and errors in muscle coordination. The autopilot, on the other hand, detects flight deviations the instant they occur and makes the required correction of the airplane's controls quickly. When properly adjusted, the autopilot will smoothly return plane to straight-and-level flight after an off-course deviation, without over-control or under-control.

Acts on Rudder, Ailerons, and Elevator

An airplane is maneuvered by displacing three controls: (1) The rudder, for turns; (2) The ailerons, for selecting rolls and banks during turns; (3) The elevator, for making the plane ascend or descend. Thus for automatic flight three separate control channels are required, each consisting of a servo motor acting on one set of control cables, a gyro-controlled amplifier channel

to make the servo rotate in the correct direction for the correct length of time, and the adjusting potentiometers in the autopilot control panel. These features of an autopilot installation are shown in simplified form in Fig. 1.

A pitch-axis deviation (such as sudden dropping of the nose of the plane) calls for corrective action by one control channel only, that serving the elevators. All other deviations necessitate corrective action by all three channels. Thus, if the right wing drops, correction is made by moving the right aileron downward and the left aileron upward. However, since the air under a wing is at higher pressure than air above a wing, the right aileron causes more drag than the left, and the plane tends to deviate to the right. Therefore, both the rudder and the elevator must be moved with the ailerons to correct the original deviation and to prevent loss of altitude.

In the autopilot, ingenious use of potentiometers in balanced a-c bridge circuits provides the required inter-relation of control

actions in an automatic manner.

The electronic features of the three channels of a C-1 autopilot are essentially identical, and hence only the circuit of one channel need be analyzed in detail. By considering the turn-control channel in simplified form as shown in Fig. 2, with amplifier and control stages omitted and with the multitudinous potentiometers lumped as a single potentiometer in an a-c bridge circuit, the action of the entire autopilot can be more readily understood.

Analysis of Autopilot Circuit

When the a-c bridge is balanced, no a-c signal is applied to the two grids of the 7N7 discriminator tube and no plate current flows since the d-c bias is fixed at cutoff by a d-c bias source.

The two plates of the discriminator tube are connected to separate secondary windings of the power transformer in such a way that at the instant when one plate is positive with respect to the cathodes, the other plate is negative. The other ends of these secondary windings are connected through the two

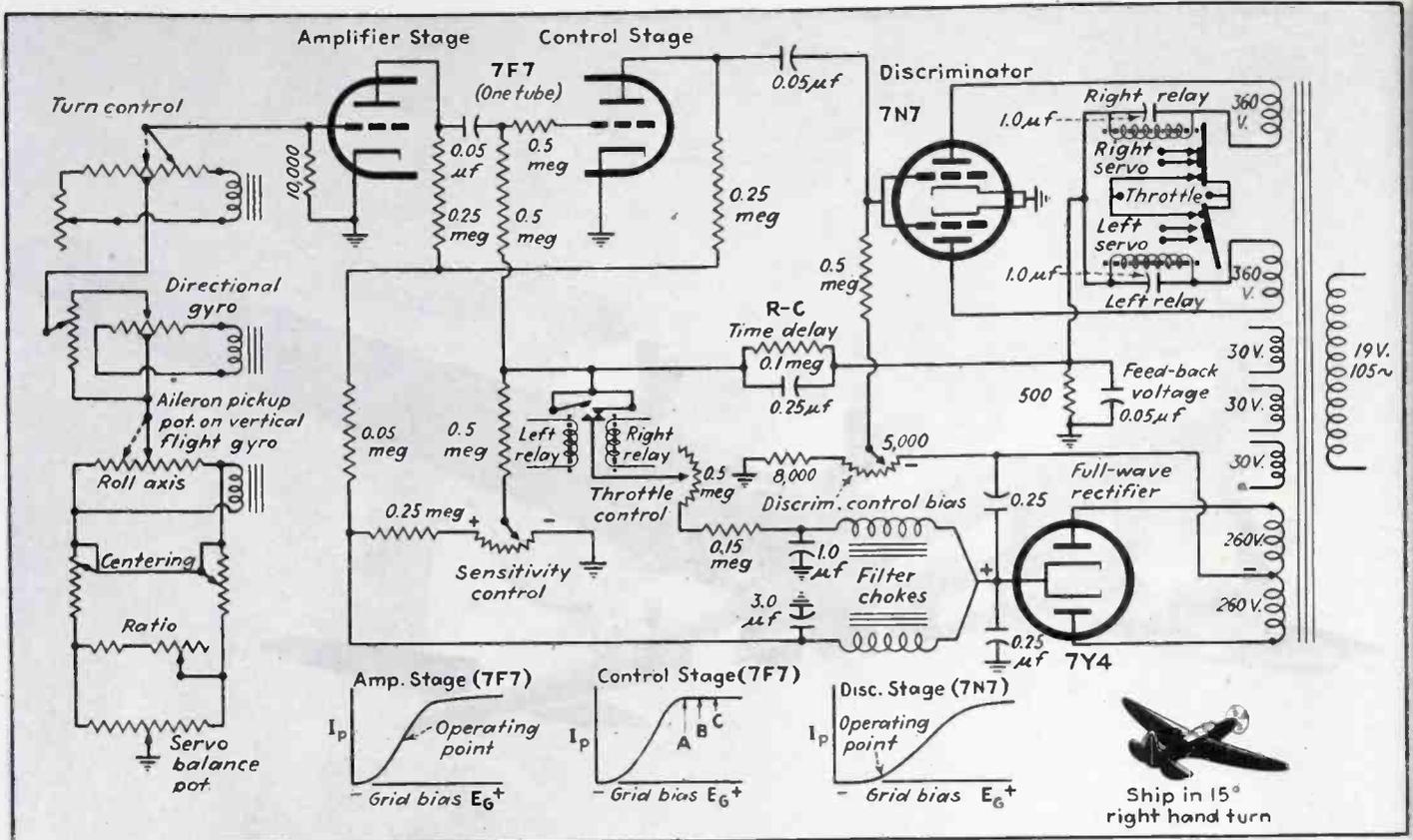


FIG. 3—Complete schematic circuit for the aileron control channel, with characteristic curves showing operating points of the tubes. The complete a-c bridge network for this channel, at the left, provides the required interlocking with other channels for properly co-ordinated turns

relay coils and a feedback circuit to the grounded cathodes of the tube. The bridge circuit is energized by another power transformer, in such a way that when plate No. 1 is positive, the right end of the potentiometer (pot) is positive as shown in Fig. 2, and when plate No. 2 is positive the left end of the pot is positive.

With the tube biased to cutoff, the positive half of any a-c signal applied to the grids will cause plate current to flow through the tube section having a positive plate at that instant. On the succeeding negative half of the signal, the plate current of the tube drops to zero because a swing beyond cutoff cannot cause variations in plate current.

Assume that a deviation of the airplane or operation of the turn-control knob by the pilot causes an unbalance in the bridge circuit, represented by movement of the wiper on the pot toward the right in Fig. 2 as shown. The signal produced by this bridge unbalance is fed through the amplifier and control stage (not shown in Fig. 2) to the grids of the discriminator tube. At the instant when the right end

of the pot is positive, polarities in the circuit will be as indicated on the diagram. The grids are both positive with respect to the cathodes, but only plate No. 1 is positive. Therefore, electrons are attracted by plate No. 1 and current flows through the right relay coil, simultaneously charging the capacitor connected across the relay. Operation of the right relay closes the circuit through one operating solenoid in the corresponding servo unit, producing the required correcting movement of the rudder. Plate No. 2 is negative and hence passes no current at this time.

One-half cycle later, the right end of the pot and both grids are negative, hence no plate current flows even though plate No. 2 is positive. The right-turn relay remains closed, however, because the capacitor connected across the relay coil discharges its stored-up energy through the coil. Thus, the right-turn relay is kept closed all the time the pot wiper is toward the right and calling for a right turn.

When airplane deviation causes the wiper on the pot to move to the left of center, exactly opposite conditions prevail. Plate No. 2 is posi-

tive at the instant when both grids are positive, hence current flows through the left-turn relay coil and charges its holding capacitor. This actuates the other solenoid in the servo unit, causing opposite movement of the rudder.

The bridge circuit in Fig. 2 is represented by a single pot for simplicity of explanation, with the center-tap serving as the balance point. Actually, the balance point of the bridge circuit is not fixed, but will shift from side to side depending upon the relative positions of all the wipers in the bridge circuit of the channel.

Complete Circuit for Aileron Channel

The complete circuit for one channel is given in Fig. 3, including the various potentiometers that make up the three a-c bridge circuits feeding this particular channel. The a-c voltage produced by bridge unbalance is amplified by the first section of a 7F7 double-triode, then fed to the control stage where the signals are sorted according to strength. Very small signals are rejected, weak signals are strengthened, medium signals are passed intermittently, and strong signals are

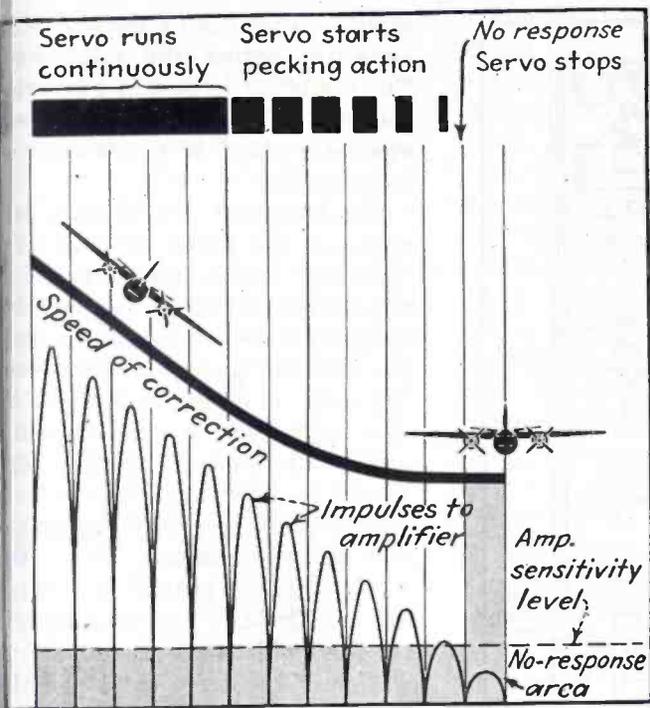
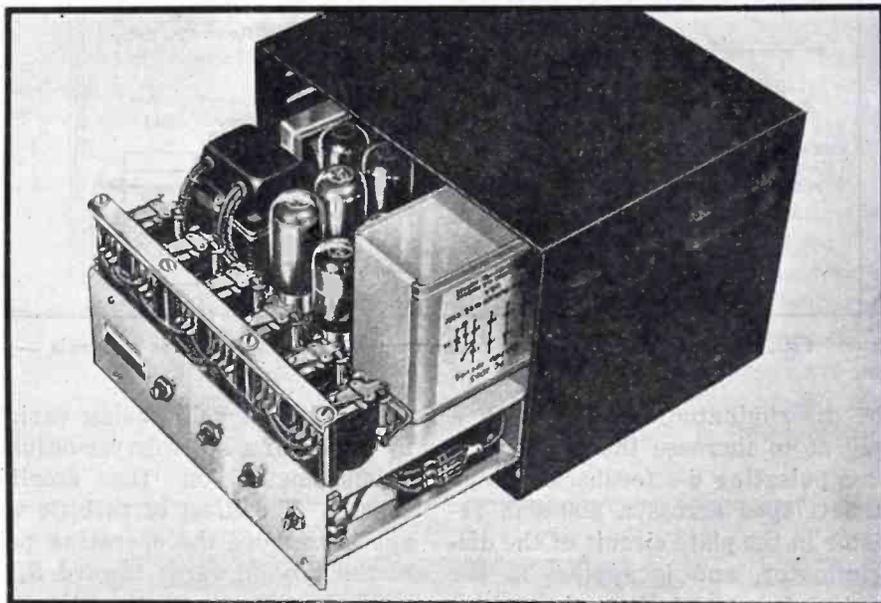


Fig. 4—Curve showing how speed-of-correction decreases as plane returns to right-and-level flight after an extreme deviation

MOVE RIGHT: C-1 autopilot as normally installed in an AT-11 airplane, with insets showing the three remotely located units. In other types of aircraft the units are not generally arranged as compactly as here. Identified parts are: 1—directional stabilizer in nose of airplane; 2—rudder servo; 3—junction box; 4—aileron servo; 5—amplifier unit; 6—rotary inverter; 7—elevator servo unit; 8—vertical flight; 9—autopilot control panel; 10—pilot direction indicator on instrument panel

RIGHT: Amplifier unit of autopilot, with cover removed and chassis pulled out to show the relays and some of the seven tubes making up the three amplifier channels



passed continuously to the discriminator tube. To accomplish this sorting action, three separate control voltages are applied to the grid of the control tube in the form of a composite d-c bias acting in series with the a-c signal coming from the amplifier stage. By inserting a 0.5-megohm resistor in the grid lead of the tube, characteristic curve like that at the bottom center in Fig. 3 is obtained for the control tube. When the combined grid voltage is negative this resistor has no effect; when the grid swings positive, however, the resulting grid-current flow through the resistor develops across it a voltage drop that leaves only a fraction of the applied posi-

tive voltage actually on the grid. Positive voltage swings thereby have no appreciable effect on plate current, and the characteristic curve levels off sharply at point A on the curve. The three control voltages, called sensitivity voltage, feedback voltage and throttling voltage, serve to shift the operating point of the control tube along section A-B-C of the curve.

Effects of Control Voltages

The first control voltage, which eliminates small signals, is called *sensitivity voltage* because it controls the sensitivity or "alertness" of the autopilot control system. This voltage is obtained from a variable voltage-divider connected in the

power-pack circuit of the amplifier, with the control knob being located on the autopilot control panel alongside the pilot. Operation of this control regulates the grid voltage between A and C (Fig. 3). At A, sensitivity is high because the negative peaks of even very small signals will cause the plate current to fluctuate and transmit a signal to the discriminator tube. Normal setting is at B, except when extreme accuracy of flight control is required during bombing runs.

The second control voltage, which prevents chattering of the relays when signals are just barely strong enough to offset the positive sensitivity voltage, is called *feedback voltage* because it is fed back from

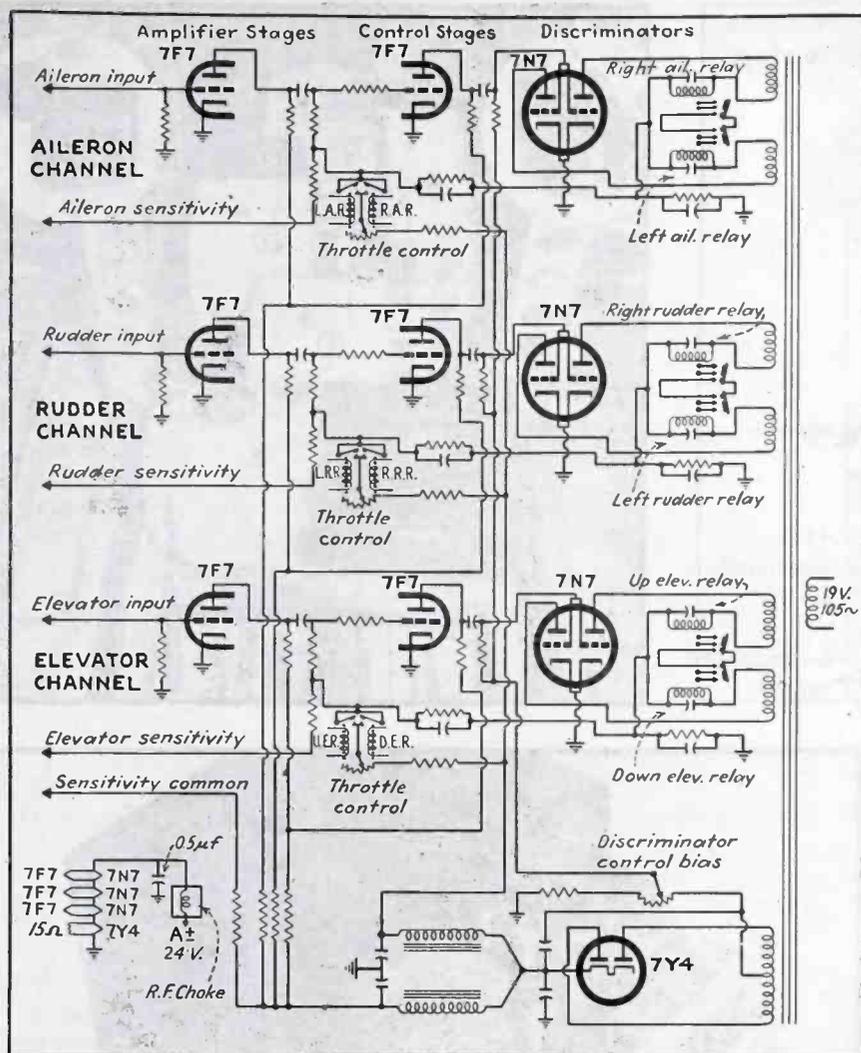


FIG. 5—Schematic diagram of 7-tube amplifier serving all three channels

the discriminator stage in such a way as to increase the sensitivity. This pulsating d-c feedback voltage is developed across a 500-ohm resistor in the plate circuit of the discriminator, and is applied to the control tube grid through a time-delay network that acts in conjunction with the third control voltage. When the sensitivity control is set at A and a weak a-c signal arrives, the feed-back voltage serves to increase the sensitivity of the control stage still more by shifting the bias point slightly to the left of A. This increases the amplifying effect of the tube, producing strong, firm closing of the proper relay in the discriminator plate circuit.

Pecking Action

The instant that a relay closes in the discriminator circuit, extra contacts on the relay apply the third control voltage, called *throttle voltage*, to the grid of the control tube. This throttle voltage is a positive d-c voltage obtained from the power

pack, with its value being variable by means of a screwdriver-adjusted potentiometer on the amplifier chassis. The effect of throttle voltage is to move the operating point of the tube upwards toward B, decreasing the size of the plate current variations resulting from the given input signal. The tube continues to operate here until, as the servo unit gradually balances the bridge circuit, the a-c signal diminishes to the point where the discriminator relay opens. This removes the throttle voltage and the operating point moves back toward A. Now the signal is strong enough to close the relay again, but this time only for an instant because the throttle voltage is again applied to the tube to block the signal. Thus, the relay is made to open and close repeatedly, causing intermittent servo operation as the balance point is approached.

The rate at which the relay opens and closes is determined by the R-C time-delay network in the feedback

circuit, as well as by the size of the capacitor across the relay itself. The net effect is that of preventing the signal from closing the relay again for about 15 cycles after the relay opens.

The resulting intermittent operation of the servo unit is called "pecking" action. Its purpose is to prevent over-control of the airplane by making the controls move slowly into position as the balance pot in the servo unit approaches its balance point. The amount of control surface movement during each "peck" is determined by the relay contact gaps, the relay spring tension, and other factors. The setting of the throttle control determines the amplitude of the smallest signal that will cause continuous operation of the servo unit, while the setting of the sensitivity control determines the signal amplitude below which servo motion stops entirely. The effects of these controls on the speed of flight correction are illustrated in Fig. 4.

Combined Amplifier Circuits

The complete circuit for the three amplifier channels and the power pack of the autopilot (integral in one small chassis) is given in Fig. 5. Parts values for the elevator and aileron channels are essentially as given in Fig. 3 for the rudder channel. Filament power is obtained directly from the 24-volt aircraft storage battery, while 19-volt, 105-cycle power to energize the primary of the power transformer is obtained from a small rotary inverter operating from the storage battery. Connections at the left in Fig. 5 go to the a-c bridge circuits for the respective channels and to the manual adjustments provided for use by the pilot. The relays at the right all control solenoids actuating the clutches and brakes in the servo units.

Servo Motor Units

The servo unit used to supply the mechanical force to the control surfaces for each channel consists of an electric motor driving a cable drum through a gear-reduction system and a reversible differential assembly incorporating solenoid-actuated friction clutches and brakes. The cable drum is connected to its control surfaces by $\frac{1}{8}$ -inch flexible

steel cables which attach to the main control cables of the plane.

The shunt-wound 1/20-hp d-c motor in each servo unit operates directly from the aircraft storage battery, and runs continuously in the same direction while the autopilot is in operation.

The power transmission system that couples a servo motor to its cable drum is illustrated in Fig. 6. The motor pinion *A* meshes with clutch gear *B*, which in turn drives clutch gear *C*. Each of these gears has a cork insert on the side away from the motor. The gears rotate continuously in opposite directions while the autopilot is in operation.

The clutch gears rotate on ball bearings which are fitted to two parallel operating shafts, *D* and *E*, in such a way that the ball bearings and gears are free to slide a limited distance along the shaft. The shafts in turn are free to slide endwise in their bearings in the servo unit frame.

essential drive gears *L* and *M*. The gears rotate freely on the differential shaft, one on each side of the differential crosshead which supports the two crosshead bevel pinions. Rotation of the crosshead is transmitted to the cable drum through the cable-drum pinion.

Between the clutch gears and their adjacent clutch-and-brake disks are coil springs *N* and *O*, which press the ball-bearing housings of the clutch gears in one direction against clutch arms *P* and *Q*, and press the operating shafts *D* and *E* in the other direction against brake arms *R* and *S*.

Two brake solenoids, *T* and *U*, one on each side of the motor, operate pullrods which compress brake tension springs *V* and *W*. The tensions of these springs, applied through brake arms *R* and *S* to the ends of the operating shafts, force the brake surfaces of the clutch-and-brake disks against their cork-faced brake rings.

Two operating solenoids *X* and *Y* apply pressure through pushrods against clutch arms *P* and *Q* whenever the operating solenoids are energized. The clutch arms force the rotating cork-lined clutch gears against the clutch-and-brake disks.

relays in the amplifier. In series with each operating solenoid is a cam-operated limit switch which prevents the servo unit from driving the control surfaces against their mechanical stops. A 0.5- μ f capacitor in parallel with each solenoid-switch combination prevents arcing of the relay contacts.

The balance pot, by balancing out the original deviation signal, controls the amount of cable-drum rotation resulting from a given deviation of the airplane. Its wiper is fastened to the cable drum by means of a friction clutch that facilitates centering the wiper at the electrical center of the pot when the control surface is in normal flight position.

As soon as the autopilot master-switch is turned on, the motors in all three servo units begin to run. Each motor drives its two clutch gears in opposite directions. These gears rotate freely on their operating shafts and no motion is transmitted to the clutch-and-brake disks which are in their neutral positions. Therefore, the cable drum can be rotated freely even though the motor is running, and the servo units will not interfere with manual operation of the controls until the pilot engages the servo brakes.

After the servo brakes have been engaged the operation of the servo unit takes place in the following

Working Sequence of Servo Unit

Operating solenoids are energized individually by the closing of



autopilot control panel, mounted within convenient reach of the pilot. With the autopilot in control at any given altitude, the plane can be maneuvered by finger-tip adjustment of the turn-control and elevator knobs or by similar remotely located knobs near the bombardier

Firmly attached to each operating shaft is a clutch-and-brake disk (*F* and *G*) which has two flat friction surfaces. One surface faces the cork insert in the adjacent clutch gear and the other faces a similar cork insert (*H* and *I*) in the brake ring fastened to the servo unit frame.

Also firmly attached to the operating shafts are gears *J* and *K* respectively, which mesh with differ-

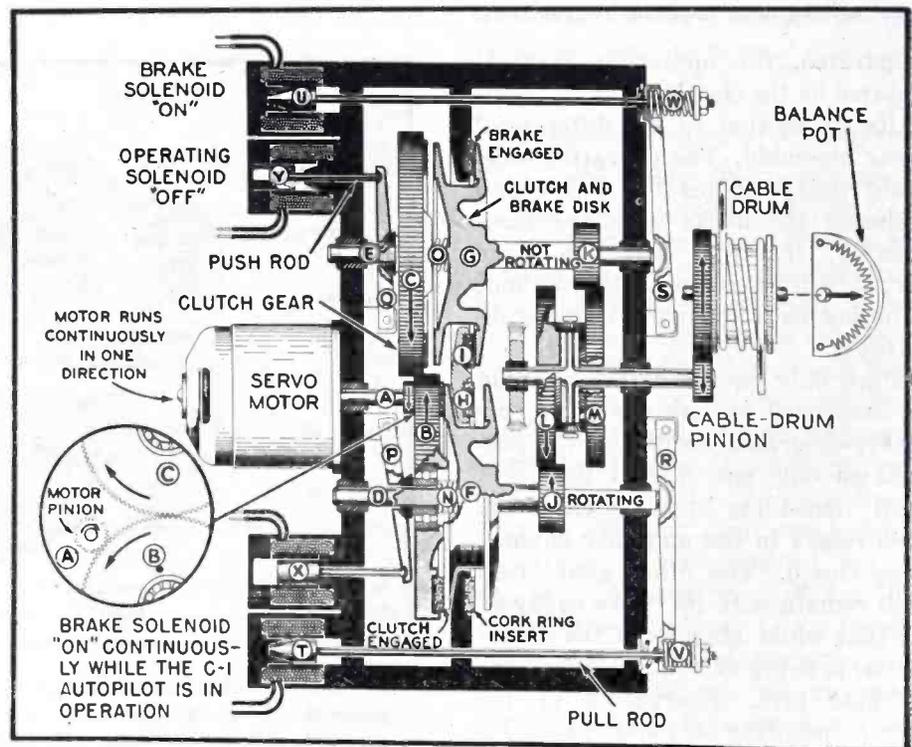
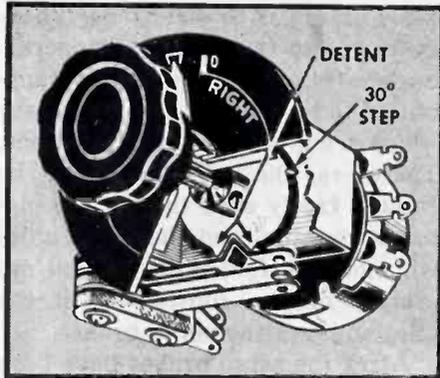


FIG. 6—Power transmission system of a servo unit

manner: When an a-c bridge or pilot-operated control transmits a signal to an amplifier, calling for movement of a particular control surface, the amplifier channel responds by closing one or the other of its two relays. The relay contacts then complete a d-c power circuit that energizes the correct operating solenoid in its servo unit. This causes the solenoid plunger and push-rod to move in against the clutch arm, which in turn forces the constantly rotating cork-faced clutch gear against the clutch surface of the clutch-and-brake disc. Continued inward movement of the clutch arm moves the entire clutch-and-brake disc assembly lengthwise, compressing the brake tension spring and forcing the brake surfaces apart.

As soon as the brake surfaces are



Construction of the turn control, showing the on-course detent in the cam and the 30-degree step in the cam to caution the pilot making turns requiring steeper banks

separated, the operating shaft is rotated by the clutch gear and transmits its motion to the differential gear assembly. The operating solenoid thus engages the clutch and releases the brake with the same motion, insuring that the cable drum will start instantly without slipping back during the engaging process.

Since only one operating solenoid is energized at any one time, the above-described condition will prevail on only one side of the servo unit, depending upon which of the two relays in the amplifier channel was closed. The other gear train will remain with its brake engaged, so that while one side of the differential is being driven, the other side is held firm. Energizing of the other operating solenoid causes reverse rotation of the cable drum.

At any time the human pilot may open the engaging switch on the autopilot control panel, and thereby release both brakes in the servo unit. When both brakes are released, the operating solenoids cannot cause cable drum rotation because the differential is free to idle.

Turn Control

While the airplane is flying under autopilot control, the pilot or bombardier can maneuver the airplane to make a properly coordinated turn. This is done through the turn control incorporated in the control unit. A corresponding but separate control is provided for operation of the airplane from a remote location by the bombardier or flight engineer.

The turn control consists of a knob-operated pot combined with a triple-contact spring-leaf switch, operated by a cam on the same shaft. This pot is connected into the aileron and rudder bridge circuits in such a way that any displacement of the pot wiper produces signals which result in coordinated movement of ailerons and rudder to produce a properly banked turn.

When the turn control knob is at the center position, the cam switch is open, but it closes when the control knob is moved in either direction to make a turn. Closure of the switch locks the directional gyro so that it cannot put in signals to

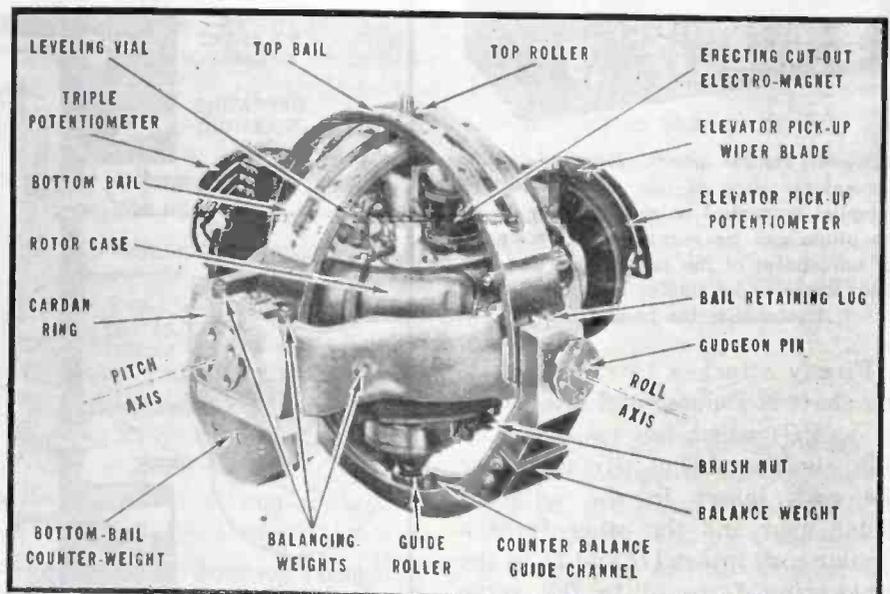
oppose desired turning maneuvers.

Besides a detent which holds the knob at center and simultaneously opens the switch, other steps are provided on the cam to indicate the approach of the airplane to the maximum 40-degree banking limit inherent in the autopilot system. Humps are provided on either side of the detent to stop the free rotation of the knob at the zero point, so the pilot will be reminded to let the aircraft return to straight-and-level flight before he brings the knob back to the center to restore autopilot directional control.

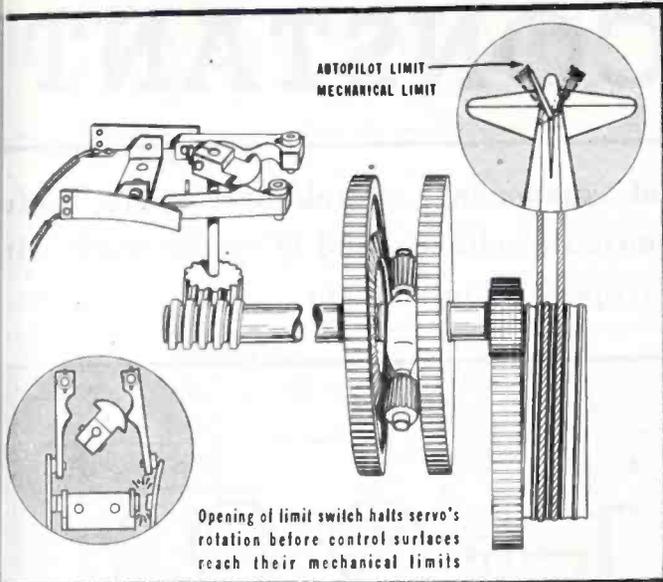
Adjusting the Centering Controls

Before engaging the servo units, the pilot must mechanically trim the airplane for straight-and-level flight. This establishes each servo balance pot wiper at a position corresponding to mechanical trim of its control surface. The pilot then adjusts each centering knob on the autopilot control panel to align the electrical balance point of each bridge circuit with this mechanical trim position of the balance pot wiper. After the engaging switches have been snapped on, the autopilot system, by always returning the balance pot wiper to its trimmed position, will keep the airplane in straight-and-level flight.

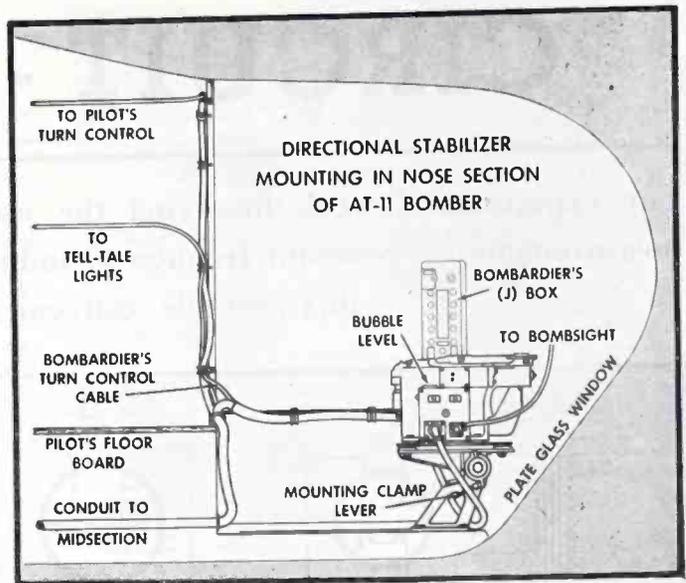
Directly above each centering control knob is a pair of indicating lights which are connected in



Vertical gyro of autopilot, with housing removed to show the erecting mechanism that keeps the gyro lined up with the pull of gravity despite rotation of the earth. The gyro rotor is a cup-shaped mass surrounding and driven by an electric motor in the center of the assembly



Example of limit switch used to prevent a servo unit from jamming the control surfaces of the plane against their stops



This gyro detects off-course deviations and causes potentiometers to produce signals calling for the required maneuver

parallel with the operating solenoids of the corresponding servo unit. One light or the other of each pair is illuminated whenever the autopilot amplifier is calling for servo unit rotation, whether or not the servo unit is engaged. Thus, when the pilot is engaging the autopilot to the airplane, the illumination of either tell-tale light indicates that the balance point of the bridge circuit is not lined up with the trim position of the balance potentiometer, and further adjustment of the corresponding centering control is required.

Example of Operation

A step-by-step description of the operation of the autopilot in correcting pitch-axis deviation will give the simplest fundamental principles involved in correcting deviations, for aileron or rudder movements are required for pitch axis deviations.

When the airplane is in straight-and-level flight, the elevator pickup pot in the gyro is at its normal position and the balance pot of the elevator servo is centered, holding the elevator control surfaces in their normal, level-flight position. Under this condition the bridge circuit is balanced and no correcting signal is applied to the amplifier.

Assume now that a sudden air current raises the nose of the airplane. The gyro case and its attached elevator pickup pot tilt with the plane, causing displacement of the pot wiper and unbalancing of

the bridge circuit, with the result that a correcting signal is applied to the elevator channel. This causes the down-elevator relay in the amplifier channel to close, sending a down-elevator impulse to the elevator servo unit. The servo unit responds by driving the elevator control surfaces downward by means of cables, thereby lowering the nose of the plane. The direction of rotation is such that the balance pot wiper on the servo unit approaches a position where the bridge circuit will again be balanced.

As the airplane begins to level off, the pickup pot in the vertical-flight gyro begins to return to its normal position. At some intermediate position the bridge circuit will again become balanced and the down-elevator relay will be released. At this point the servo cable drum will stop, with down-elevator still applied.

It is now necessary to return the control surface to neutral to prevent over-control. This is achieved automatically because as the plane continues leveling off, the gyro unbalances the bridge circuit in the opposite direction. Now the up-elevator relay closes, resulting in opposite rotation of the servo unit and upward movement of the elevator, back toward its normal level-flight position. This principle is basic in aircraft control; after a correction has been applied by moving a control surface away

from its normal position, the control surface must be returned to normal again.

As the airplane approaches level flight attitude, the speed of control-surface movement is gradually reduced by the autopilot. By the time the airplane reaches its normal level-flight attitude, the bridge circuit is again balanced, this time with all pots electrically centered, and the autopilot action ceases. The separate steps described above actually take place in a gradual progression, each movement blending into the next to produce smooth correction that may be rapid at first, but which tapers off smoothly as the plane resumes its normal flight attitude.

Commercial Future of Autopilot

In announcing the development of the C-1 autopilot and the electronic turbo regulator system described in May 1944 *ELECTRONICS*, W. J. McGoldrick, vice-president in charge of aeronautical engineering for Minneapolis-Honeywell Regulator Company, pointed out that these electronic controls take over some of the duties of the flight crew and enable the pilot and flight engineer to perform their work more effectively in the rarefied air of the upper atmosphere. Planes like the B-29 become easy to fly despite their huge size and weight, indicating an important role for these electronic controls in passenger and freight Stratoliners of the future.

CHECKER



The circuit-constant checker. At the left are the tuning indicator, band selector, connections for external vtvm, and bucking-voltage potentiometer. Below the large oscillator-tuning control are the on-off and the Q switch. External tuning-capacitor receptacle is at the right

connected across the measuring terminals of the probe and the oscillator is adjusted for resonance as indicated by the 6E5. Since the pentode will act as a frequency multiplier, resonance will be indicated at sub-harmonics of the tank fundamental, but this is not objectionable because the developed tank-voltage is always greater at the fundamental frequency. Also the fundamental is the highest frequency at which any voltage can be developed.

Capacitance can be measured by connecting a standard tank and the capacitor to be measured across the measuring terminals. When the oscillator is adjusted for resonance $C = 1/\omega^2 L$ where C is the total tank capacitance. The capacitance scales should preferably utilize the two lowest frequency bands. The low end of the calibration is sufficiently broad to allow capacitance measurements to be made on video amplifiers, while the upper limit is about 100 $\mu\mu\text{f}$. With the particular oscillator ranges used, a 456-kc transformer with an additional hunt capacitance serves as a standard tank.

The i-f transformer padder is utilized as a zero positioner for the capacitance scales. It is advisable to calibrate the capacitance scales

against a standard Q meter or some other capacitance standard, rather than by computation based on the inductance and total capacitance of the standard tank.

Inductance measurements are made in a similar manner by using a fixed capacitance standard. With a 387 $\mu\mu\text{f}$ standard and the 13 $\mu\mu\text{f}$ residual probe capacity, the formula for L simplifies to $L = 63.2 \times 10^9 / f^2$ where f is in kc and L is effective series inductance in μh . The effective series inductance may differ from the true inductance by less than 2 percent for coils having less than 10 $\mu\mu\text{f}$ of distributed capacitance. The inductance range is 1 μh to 9 mh.

Determinations of Q can be roughly made by using the frequency-variation method. If the coil is shunted by an air capacitor

$$\text{Coil } Q = \left(\frac{F_r}{F_r - F_o} \right) \left(\frac{F_o}{F_r + F_o} \right) \left(\sqrt{\frac{E_r^2 - E_o^2}{E_o^2}} \right)$$

where F_r and E_r are the resonant frequency and voltage respectively and F_o and E_o are the off-resonant frequency and voltage respectively.

When $E_r/E_o = \sqrt{2}$, as is the case when using the instrument Q-switch—and also assuming that the first two terms of the equation above are equal to $\frac{1}{2} F_r / (F_r - F_o)$ —the equation simplifies to $Q = F_r / \Delta f$ where Δf is the frequency difference between the points at which response is down to 71 percent. The above assumption contributes error at low Q values, but it is less than the accuracy of measurement. It is best to find Δf by multiplying dial-division difference by kc per division for the particular portion of the dial used. For very high Q values, this method again becomes approximate because of the inability of determining Δf closely enough and also because of the finite dynamic plate resistance of the pentode amplifier and diode.

These Q measurements are simple but, at best, they are quite rough. When greater accuracy is desirable, the reactance-variation method is recommended. Still other measuring methods will suggest themselves, based on a high-impedance r-f source.

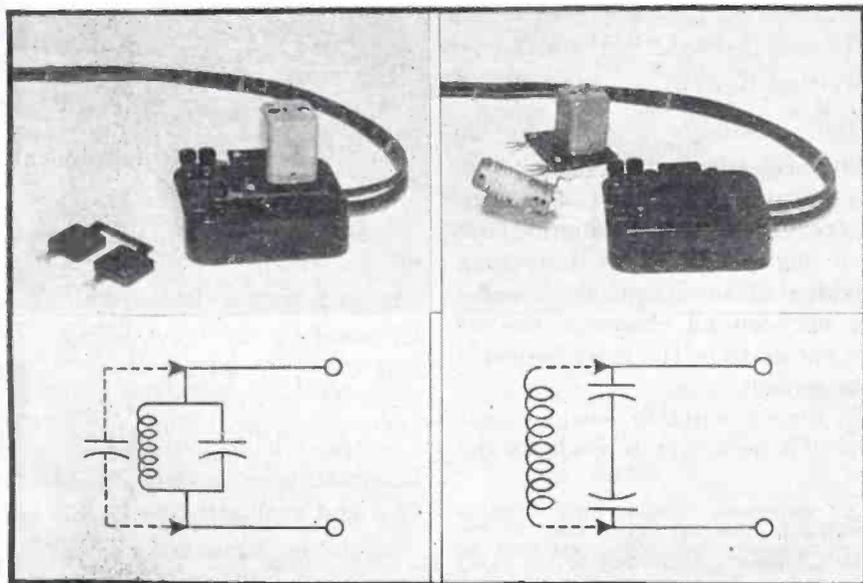


FIG. 2—Probe, which is permanently connected to checker proper, is shown at left equipped with resonant tank for capacitance measurements and at right with capacitance standard replacing tank, and inductance in place for checking

Frequency Allocation for

THE problem arises, in many radio-electronic applications, of selecting the frequencies to be assigned to each of a group of frequency-selective control circuits so that the total cross-talk due both to adjacent-channel proximity and to system distortion does not exceed a prescribed value.

A usable frequency distribution plan could be obtained by experimentally trying different frequency combinations, or by empirically arranging selectivity response curves for each channel on a frequency scale until a satisfactory compromise arrangement were obtained. The first method has obvious utility only when the number of channels is small, whereas the second provides no information regarding the effect of system distortion.

In the event that all channel filters are of the same type and have similar Q factors, as is commonly the case, a solution can be developed based upon an analytic allocation plan which will provide equal electrical performance on all channels and from which the problems arising from operation of any number of channels can be solved.

Logarithmic Distribution

Just as the frequency response of each of a series of selector filters of equal electrical characteristics but different channel frequencies can be written by identical equations when expressed in percents of their respective channel frequencies, so if the frequency separation between successive channels can be written by identical equations, each channel will be as well situated electrically as any other. If the percent frequency separation between channels is constant, such identical equations can be written. The requirement that no one channel be favored over the others in its separation allotment is fulfilled if separation be based on a constant percent of the mean of the respec-

This method for assigning channel frequencies takes into account the response of the filter circuits, and cross-talk due to channel proximity. It provides the same electrical performance on all channels, and distributes the channels so that harmonic interference is minimized

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tive channel frequencies. That this is so will become more apparent when the expressions for band allocation are derived.

It will be shown that a logarithmic distribution provides this constant mean-frequency separation.

Let:

n = channel number, where channels are numbered consecutively from 1 to N starting with the lowest-frequency channel

f_n = frequency of any specific channel number n

f_{max} = frequency of highest-frequency channel, numbered N

f_{min} = frequency of lowest-frequency channel, numbered 1

m = slope constant, defined by the following:

$$n = 1 + m \log (f_n / f_{min}) \quad (1)$$

$$dn = m(df_n / f_n) \log_{10} e = 0.434m(df_n / f_n) \quad (2)$$

Rewriting Eq. (2),

$$dn/df_n = 0.434m/f_n \quad (3)$$

This equation states that channel separation is related to the channel frequency by a constant. That is, a logarithmic allocation plan provides mean frequency separation between all channels, as has been shown to be the most desirable arrangement.

To obtain suitable design equations it is necessary to evaluate the

slope constant, m , and obtain general expressions for any channel frequency and for the channel separation.

If dn is made equal to unity, Eq. (2) reduces to

$$df_n / f_n = 2.303/m \quad (4)$$

Writing the general Eq. (1) for the particular channels $n1$ and $n2$ where the 1 and 2 indicate different channels, $n2$ being higher than $n1$ but in no other way specifying the location of these two channels in the frequency spectrum, the following expressions are obtained:

$$n1 = 1 + m \log (f_{n1} / f_{min}) \quad (5)$$

$$n2 = 1 + m \log (f_{n2} / f_{min}) \quad (6)$$

$$n2 - n1 = m \log (f_{n2} / f_{n1}) \quad (7)$$

$$m = \frac{n2 - n1}{\log (f_{n2} / f_{n1})} \quad (8)$$

Rewriting Eq. (1) in exponential form

$$f_n / f_{min} = 10^{(n-1)/m}$$

or

$$f_n = f_{min} 10^{(n-1)/m} \quad (9)$$

Eliminating m between Eq. (8) and (9), and letting $n1 = 1$, and $n2 = N$

$$f_n = f_{min} 10^{[(n-1) \log f_{max} / f_{min}] / (N-1)} \quad (10)$$

Eliminating m between Eq. (4) and (8), and evaluating as in Eq. (10)

$$\frac{df}{f} = \frac{2.303}{N-1} \log \frac{f_{max}}{f_{min}} \quad (11)$$

* All statements, opinions and assertions appearing in this paper are those of the writer and are not to be construed as official or reflecting the views of the Naval Department or the naval service at large.

Multi-Channel Systems

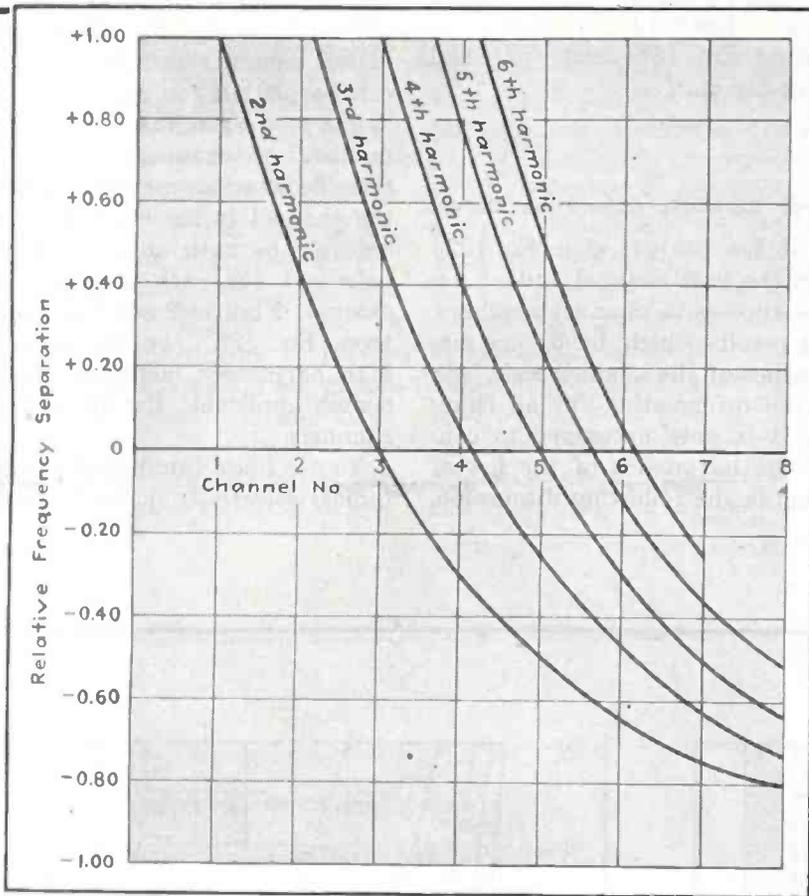


FIG. 1—When the ratio between successive channel frequencies is $\sqrt{2}$, the separation between a given harmonic of the lowest channel and any of the other channels is as shown. The graph can be used for harmonics of other channels by shifting the channel No. scale to the left

Equation (10) gives the frequency of any channel n as a function of the maximum and minimum channel frequencies and the number of channels to be contained within these limits. Equation (11) gives the mean channel separation in terms of the ratio of the highest to the lowest channel frequencies and the total number of channels.

Geometric Distribution

Allocation based upon a geometric progression is identical with results obtained by following a logarithmic distribution of channel frequencies. The logarithmic derivation has been presented because of the insight which it gives to the basic theory. However, because of the concept of channel multiplier which it introduces, the geometric

derivation will also be briefly presented.

If the frequencies of the channels are in a geometric series the expression for any channel frequency is

$$f_n = f_{min} r^{n-1} \quad (12)$$

where r , the ratio in the geometric series, will be called the channel multiplier from its physical significance.

If Eq. (12) is written in logarithmic form,

$$\frac{\log(f_n/f_{min})}{\log r} = n - 1 \quad (13)$$

it will be recognized as equivalent to Eq. (1) where

$$m = 1/\log r \quad (14)$$

By following a procedure similar to that used to evaluate m in the

logarithmic derivation, r can be evaluated.

$$r = 10^{[\log(f_{max}/f_{min})]^{1/(N-1)}} \quad (15)$$

The remainder of the derivation need not be reproduced. That the geometric and logarithmic plans of allotment are identical has been verified, and the concept of a channel multiplier has been introduced to replace the slope constant which arose in the logarithmic derivation.

Frequency Separation Between Harmonics

Having determined the plan by which channel frequencies will be allotted, it is next essential to examine the manner in which the harmonics of the channels will distribute themselves throughout the frequency spectrum. The channels can then be assigned frequencies both in accordance with the previous relations and also in such a sequence that interference in any channel from harmonics of the lower channels will be a minimum. Let:

h = the order of the harmonic

Δf = the separation between a harmonic and a channel

α_f = relative separation between channels

α_h = relative separation between a harmonic and a channel

Mathematically these terms are defined as follows:

$$\Delta f = hf_{n1} - f_{n2} \quad (16)$$

which is the frequency separation between the h order harmonic of the $n1$ channel, and the $n2$ channel itself. Relative channel separations then are

$$\alpha_f = \frac{f_{n-1} - f_n}{f_n} = 1 - \frac{1}{r} \text{ (higher channel)} \quad (17)$$

or

$$\alpha_f = \frac{f_{n-1} - f_n}{f_n} = r - 1 \text{ (lower channel)} \quad (17)$$

$$\alpha_h = \frac{\Delta f}{f_{n2}} = \frac{hf_{n1} - f_{n2}}{f_{n2}} = \frac{h}{(f_{n2}/f_{n1})} - 1 \quad (18)$$

but

$$\frac{f_{n2}}{f_{n1}} = \frac{f_{min} r^{n2-1}}{f_{min} r^{n1-1}} = r^{n2-n1} \quad (19)$$

therefore

$$\alpha_h = \frac{h}{r^{n_2 - n_1}} - 1 \quad (20)$$

In particular, if n_1 equals the first channel, $r = \sqrt{2}$, and n_2 assumes channel numbers from 1 to 8, the plot of Fig. 1 results.

Equation (20) gives the relative separation between the h harmonic of channel n_1 , and channel n_2 . However, it is not necessary to solve the equation for all possible combinations of n_1 and n_2 . The single solution plotted in Fig. 1 suffices (for cases where $r = \sqrt{2}$). If, for instance, it is required to obtain the same information for the proximity of the harmonics of channel 2 to the other channels, shift the channel numbers one unit to the left. In this manner, the relative locations of the harmonics of all the channels can be studied.

To generalize Eq. (20) further it

is necessary to eliminate the channel multiplier, which can be done as follows:

From Eq. (17),

$$r = 1/(1 - \alpha_f) \quad (21)$$

From Eq. (20),

$$r = \left[\frac{h}{\alpha_h + 1} \right]^{1/(n_2 - n_1)} \quad (22)$$

Equating Eq. (21) and (22) and solving for α_h ,

$$\alpha_h = h(1 - \alpha_f)^{n_2 - n_1} - 1 \quad (23)$$

General Harmonic Separation Curves

As in Eq. (20), if n_1 in Eq. (23) equals the first channel and n_2 assumes successive channel numbers, a plot results which, by proper manipulation of the channel axis, will give the information for all channels. It is only necessary to consider the harmonics of the lowest channel in the following discussion,

the method of generalization being understood.

Equation (23) relates the frequency separation ratio between channels and harmonics for any order of harmonic and any number of channels. As this equation involves analytic relations, without reference to specific circuit properties, separate families of curves can be plotted for each order harmonic corresponding to a specified number of channels. These will then be general curves associating the channel to harmonic frequency separations with any of the channels and for each harmonic considered. Figures 2 and 3 are plotted from Eq. (23) for the second to fifth harmonics inclusive, showing curves applicable for up to fifteen channels.

To use these families of curves, a typical selectivity curve for one of

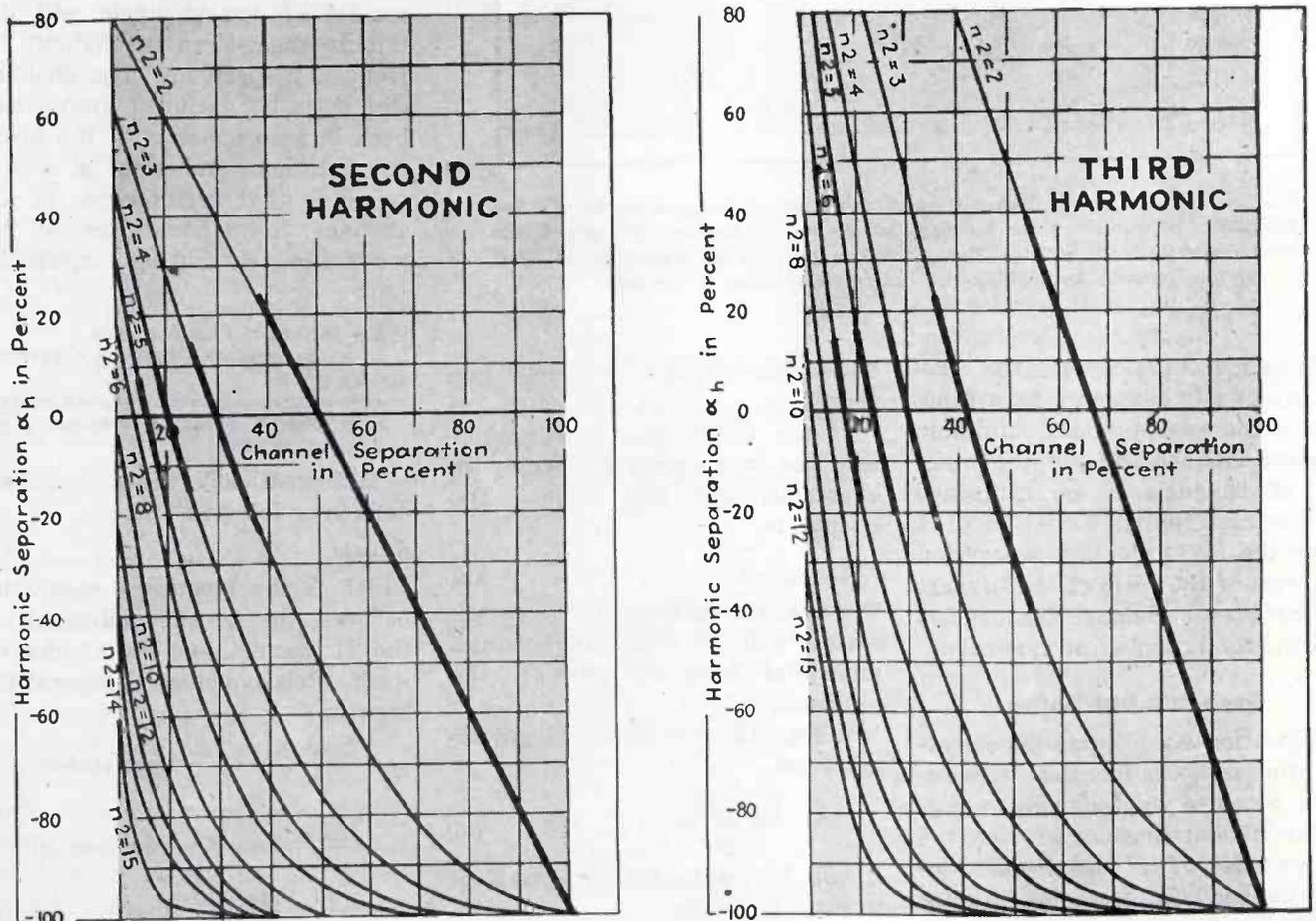


FIG. 2—General design work sheets showing the separation between a harmonic and the channels as a function of the separation of the channels themselves. Curves are plotted for systems up to fifteen channels; thus, the curve $n_2 = 6$ is for a six-channel system. The heavy-line portion of each curve indicates the cyclic variation of the optimum channel separation

the channel filters is required. Figure 4, for example, may be used to illustrate applications of the method. Shown also in this figure are selectivity curves corresponding to 10 and 25 percent total distortion. The channel information is expressed in percent separation from the channel frequency for convenience in application of Eq. (23) or of the harmonic work sheets.

Example

For a system of ten channel selectors, a channel multiplier of 1.48, and a signal distortion of 25 percent second harmonic and 10 percent third harmonic, it is desired to know the maximum cross-talk on any channel resulting from adjacent-channel proximity and harmonic distortion. Figure 4 will be used as a typical selectivity char-

acteristic for the channel filters.

The channel separation ratio determined from Eq. (17) for $r = 1.48$ is 32.4 percent and 48.0 percent respectively. Reference to Fig. 4 gives 6.5 percent (point A) and 8.5 percent (point B) cross-talk due to adjacent-channel coupling. These two values are for the two adjacent channels, one above and one below the channel under consideration. Referring to the harmonic families of curves on Fig. 2, corresponding to a 32.4 percent channel separation for a ten channel system the second harmonic will pass as close as 8.7 percent, and the third harmonic as close as 7.4 percent to the nearest channel, and on the low-frequency side. When these quantities are used in Fig. 4, it is found that for the above conditions the maximum cross-talk on the channel which is the most affected by second har-

monic from a lower channel will be 32.2 percent (point C), and on the channel similarly affected by third harmonic will be 13.0 percent (point D). The cross-talk on the lowest channel will be 8.5 percent from the second channel proximity. On the second channel, cross-talk will be 6.5 percent from first channel proximity and 8.5 percent from third channel proximity. The third channel will be affected by second and fourth channel proximity, and by 32.2 percent second harmonic from the lowest channel. The fourth channel will have channel proximity cross-talk, and in addition third harmonic from the lowest channel, and second harmonic from the second channel. The maximum cross-talk which can appear on any channel, as obtained by taking the quadrature sum of all cross-talk terms, is $(6.5^2 + 8.5^2 + 32.2^2 + 13.0^2)^{1/2} =$

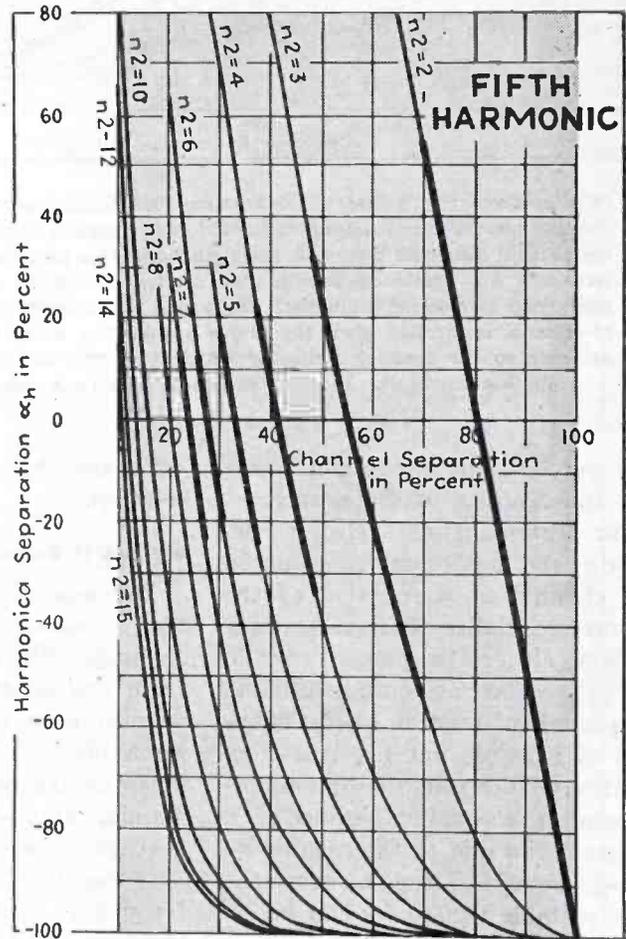
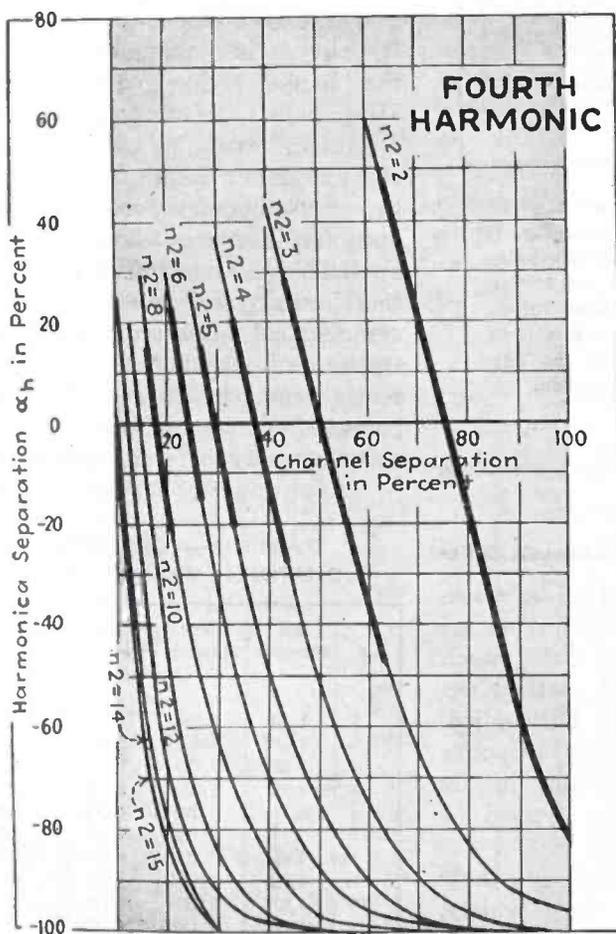


FIG. 3—These are the same type curves as in Fig. 2, but for higher harmonics. Over the heavy portion of each curve, harmonic to channel separation is small. Beyond the heavy-line regions, channel separation is either dangerously small or unnecessarily large. The end points of the heavy lines locate the optimum channel separations, a compromise between channel and harmonic interference

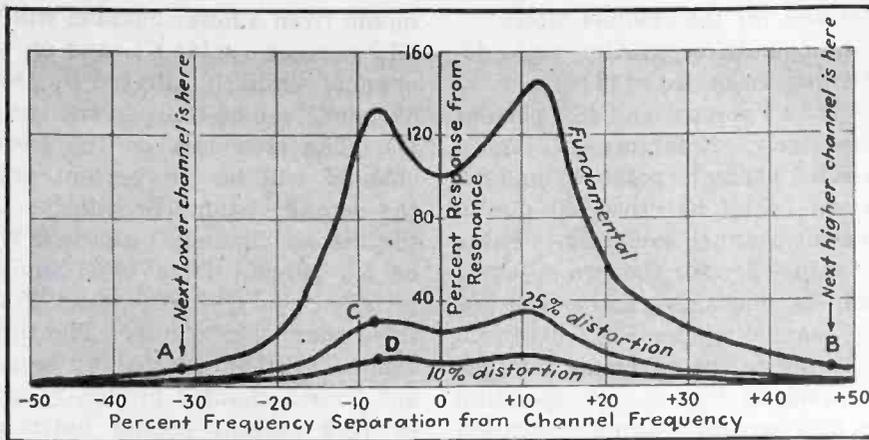


FIG. 4—Frequency response of the channel selector used in the illustrative examples. Instead of considering the distortion component as a percent of the signal, the response of the channel selector to the distortion is considered as a percent of the response to the signal. Response curves corresponding to 25 percent and 10 percent distortion are plotted on the same axis to facilitate cross-talk calculations

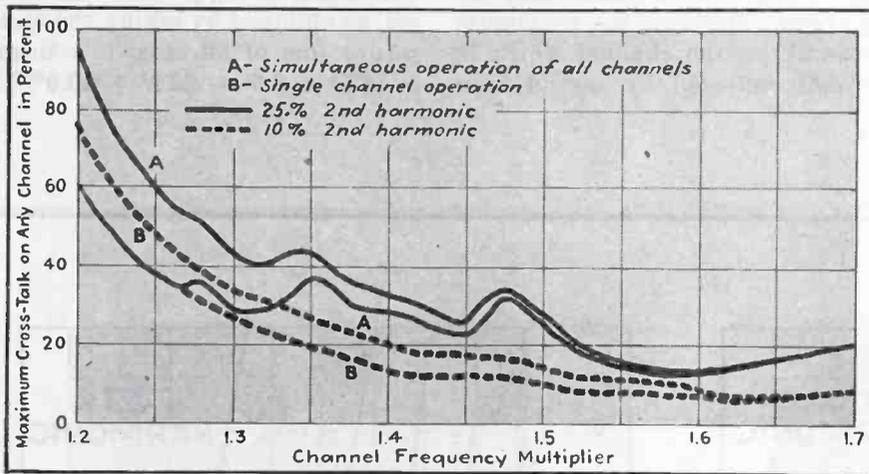


FIG. 5—From Fig. 2 and 3 the harmonic to channel separation for a given channel separation is determined. With this harmonic separation and Fig. 4, the percent harmonic cross-talk is determined. This plus the channel proximity cross-talk are combined and plotted against the given channel separation (converted to channel multiplier). Repeating this procedure for various values of channel separation gives the above graph. The utility of such a plot is in determining the channel multiplier which will give the minimum or the permissible cross-talk. The plot shown here is for a ten-channel system

36.4 percent, the maximum cross-talk the circuits must tolerate.

For a ten-channel selector, determine the maximum cross-talk on any channel as a function of the channel multiplier. The system may contain either 10 percent or 25 percent second harmonic distortion. This is a continuation of the above type of example but involves computation of the total distortion corresponding to various values of r . Figure 5 is a plot of the results obtained. From this type of curve the most suitable value of r can be selected by inspection. The ratio between the highest and lowest channel frequencies can then be computed by application of Eq.

(12), thereby providing a complete solution.

Method if Response of Channels Differ

The examples involved a selectivity characteristic typical to all channels. Where these differ much from one another the method developed here can still be applied. Each channel selectivity response must be treated separately in the manner applied to the typical or average response curve.

If the Q of the circuits and their frequency responses vary widely, however, the allocation plan can be improved by compromising results of this method with the best performance reached by experimentally

manipulating the channel frequencies. In extreme cases, it is conceivable that the latter procedure will prove most effective.

Optimum Channel Multipliers

In the process of utilizing the harmonic versus channel separation curves, it is evident that the ordinate erected at any channel separation value determines the relative frequency separation from the channel frequency for the particular harmonic involved. From these curves, it is therefore possible with the aid of a pair of dividers to determine the closest harmonic separation from any of the channels. Supplementary curves can thus be derived to designate this condition. The heavy lines of Fig. 2 and 3 show that part of the curves used to give this supplementary type of graph. An examination of such curves discloses the interesting fact that they vary cyclically, and for any harmonic there correspond specific allocation plans for channel frequency separations, which result in the greatest harmonic separation from any of the channels.

In the event the channel selectivity curves are symmetrical about the channel frequency, these operating points denote conditions for minimum cross-talk. Accordingly, the maximum amplitude points of the supplementary curves establish optimum frequency allocation plans, applicable to any filter-channel system employing elements with symmetrical selectivity responses. Optimum locations may be read directly from the curves. For purposes of tabulation, however, the accuracy may be improved by re-

TABLE 1 — OPTIMUM CHANNEL MULTIPLIERS

n	2nd Harmonic	3rd Harmonic	4th Harmonic	5th Harmonic
2	1.620	2.182	2.730	3.260
3	1.322	1.568	1.769	1.948
4	1.232	1.373	1.495	1.595
5	1.167	1.278	1.365	1.435
6	1.135	1.222	1.288	1.343
7	1.117	1.185	1.239	1.283
8	1.097	1.158	1.204	1.241
9	1.085	1.138	1.174	1.209
10	1.076	1.132	1.167	1.185
11	1.068	1.110	1.142	1.166
12	1.062	1.103	1.128	1.151
13	1.057	1.092	1.117	1.137
14	1.053	1.085	1.108	1.127
15	1.049	1.079	1.100	1.117

...ing to computation from a derived formula.

Maximum Harmonic Separation

Let α_{n1} and α_{n2} be the harmonic separation for any two successive channels. From examination of fig. 2 and 3 it is seen that maximum separation of harmonics from channels occurs at

$$\alpha_{n1} + \alpha_{n3} = 0 \quad (24)$$

By applying Eq. (23) and manipulating, there results

$$r = [(h/2)(1+r)]^{1/N} \quad (25)$$

This equation can be solved on a log-log slide rule.

In Table 1 are optimum values for the channel frequency multipliers which yield minimum cross-talk due to any harmonic up to the fifth when applied to symmetrical selectivity characteristics. The number of channels being considered for use determines the number of valid channel multipliers available from the table. For example, if five channels are contemplated, all multipliers above row 5 in the table may be considered. All other values have no meaning. The table can be similarly interpreted for other numbers of channels.

Asymmetrical Channel Selectivity Response

If the frequency response characteristic of the channels is asymmetrical, a measurement can be made of the degree of dissymmetry. Correction factors can then be applied to Table 1 for conversion to the required optimum multipliers.

Referring to Fig. 6, the response dissymmetry coefficient can be defined as the ratio of the highest to the lowest frequencies which produce equal responses.

$$k = a/b \geq 1 \quad (26)$$

From Eq. (24) and (26)

$$\alpha_{n2} + k\alpha_{n3} = 0 \quad (27)$$

Substituting Eq. (23) into Eq. (27), and evaluating at $n1 = 1$ and $2 = N$,

$$h(1 - \alpha_f)^{N-1} - 1 + k[h(1 - \alpha_f)^N - 1] = 0 \quad (28)$$

From Eq. (21)

$$(1/r)^{N-1} + k(1/r)^N = (1+k)/h \quad (29)$$

$$(1/r)^N(k+r) = (1+k)/h \quad (30)$$

$$r^N = h(k+r)/(1+k) \quad (31)$$

When $k = 1$ (i.e., the response is symmetrical about the channel frequency),

$$(r_{k-1})^N = h(1+r)/2 \quad (32)$$

When k is not equal to 1,

$$(r_{a/b})^N = h(k+r_{a/b})/(1+k) \quad (33)$$

Letting $r_{a/b}/r_{k=1} = \beta$, the ratio of the optimum channel multiplier for asymmetrical channel response to the optimum multiplier for symmetrical response, and writing $r_{a,b} = \beta r_{k=1}$ and dropping the subscript $k = 1$,

$$\beta = \left[\frac{2(k+\beta r)}{(1+r)(1+k)} \right]^{1/N} \quad (34)$$

Here β is the correction factor to be applied to the optimum channel multipliers of Table 1. Figure 7 shows correction factors for asymmetry coefficients from 1.0 to 1.5.

From Table 1 and Fig. 7, the channel multipliers giving the least cross-talk from any harmonic up to the fifth can be identified, taking into account the shape of a typical channel response curve and the number of channels.

Conclusions

A desirable choice of frequency assignment to the elements comprising a group of frequency-selective circuits appears to be based upon a constant percent frequency separation plan. This is predicated upon the condition that the circuit Q factors for the various elements are substantially alike. For this condition all channels will have identical electrical performance properties, which is normally desirable in connection with the use of frequency-selective circuits.

Separation on a constant mean percent frequency basis can be realized by utilizing a logarithmic or geometric progression plan of allocation.

A method has been developed with working equations and general curves which provides a means for solving all important problems associated with such an allocation plan, provided, however, that knowledge of the selectivity responses for the selector channels is available.

Optimum allocation plans which minimize cross-talk resulting from any harmonic are related to the degree of response dissymmetry. These can be identified for any particular problem by means of derived general expressions or the plotted work sheets.

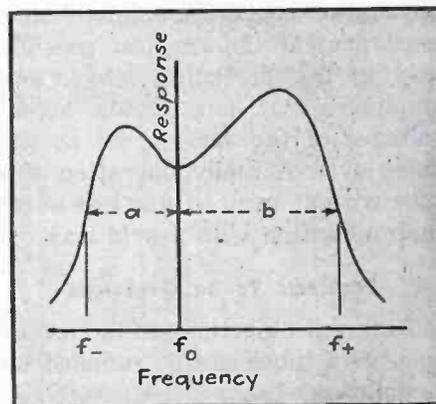


FIG. 6—Where the dissymmetry of the channel-selector filters is great a correction is introduced. The ratio of a to b is the dissymmetry coefficient of the channel-selector response curve

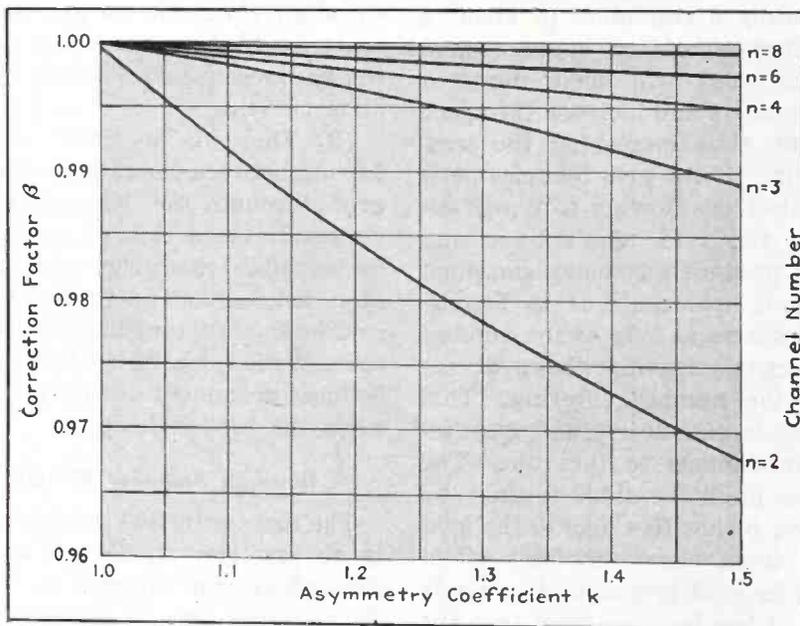


FIG. 7—To correct for selector response dissymmetry the factors given above for asymmetry coefficients through 1.5 and channels up to eight are applied to the optimum channel multipliers given in Table 1

OPEN-GRID TUBES IN LOW-LEVEL AMPLIFIERS

By ROBERT J. MEYER

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FOR CERTAIN APPLICATIONS in amplifiers requiring a high input resistance and low noise level it has been found desirable to eliminate the grid leak, and no undesirable effects resulted from using the tubes in this manner. Examples of such applications are amplifiers operating from a low-level, high-impedance source, amplifiers that must present the smallest possible load to the preceding stage, and amplifiers that must handle signal voltages of the same order as the noise level. Actually, operation of a tube with an open grid is less noisy than operation with a grid leak.

Problems To Be Overcome

Different objections to the use of open grid tubes can be summed up as follows:

(1) It has been suggested¹ that if the operating temperature of the tube is high enough, the grid will emit electrons. When this occurs in a conventional circuit, the resulting current through the grid leak (generally a resistance of about 2 megohms connected between grid and cathode) will make the grid less negative and increase the space current, thus increasing the temperature. If the grid becomes positive, electrons flowing to it will increase the grid temperature and might produce secondary emission. The grid will continue to become less negative as long as the number of electrons leaving the grid exceeds the number entering. This process is cumulative and may result in damage to the tube. The process might be aided initially by the flow of positive ions to the grid when it is negative. This effect would be most pronounced in a soft tube. It has been asserted that the use of extremely high cathode-to-grid resistance (such as an open grid) would tend to aid the process

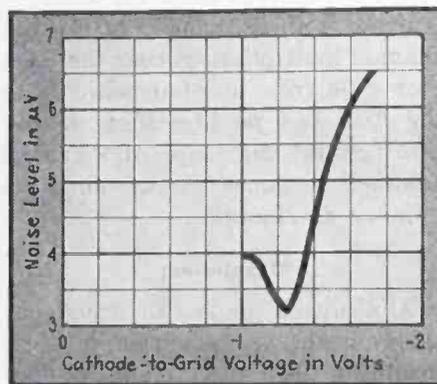


FIG. 1—Noise level vs. cathode-to-grid voltage for a 6SJ7 tube connected as a triode, with 40 $\mu\mu\text{f}$ in the grid circuit to simulate a high-impedance crystal pickup having no shunt resistance

by producing large voltage drops in the grid circuit.

(2) If the grid leak is omitted, electrons will flow to the grid from the cathode and the grid will accumulate a negative charge.² Then any slight change in the grid capacitance would change the grid potential and produce fluctuations in the plate current.

(3) There is a small current flowing between the cathode and the grid through the leakage paths. However, these leakage paths are continually changing and thus there is a random fluctuation in the grid leakage current which produces noise in the tube. This effect should be most prominent during the time when the tube is heating.

Noise in Amplifier Circuits

The three principal types of noise in an amplifier circuit are flicker, shot effect and thermal agitation. These noises can be considered as being developed by equivalent generators in the grid circuit of a noise-free tube.

The flicker voltage, which is produced by irregularities in the temperature of the heating element, is inversely proportional to the square of the frequency.

Shot noise is uniformly distributed throughout the frequency spectrum, independent of the electron velocity and independent of the manner in which the total current divides between the electrodes. The values of the shot voltage E for triodes can be calculated from the formulas³

$$|E| = 2 \times 10^{-10} \sqrt{\Delta F / g_m} \quad (1)$$

For pentodes, the formula is

$$|E| = \frac{2 \times 10^{-10}}{g_m} \sqrt{\frac{I_b}{I_b + I_a} (g_m + 8I_a) \Delta F} \quad (2)$$

The thermal agitation voltage developed by a resistor is

$$E^2 = 4KTR \Delta F \quad (3)$$

where R is the resistance, ΔF is the frequency band passed, T is the temperature in degrees Kelvin and K is Boltzmann's constant (1.39×10^{-23}).

If the impedance in the grid circuit is not a pure resistance, the resistive component is a function of the frequency and the voltage can be obtained from:

$$E^2 = 4KT \int_{f_1}^{f_2} R(f) df \quad (4)$$

These formulas apply only to wire-wound resistors or to carbon resistors in which no current is flowing.

There is always some capacitance across a resistor and this parallel combination forms a low-pass filter which affects the thermal agitation voltage e as follows:

$$e = 1.28 \times 10^{-10} \sqrt{RF_0 \left(\tan^{-1} \frac{F_2}{F_0} - \tan^{-1} \frac{F_1}{F_0} \right)} \quad (5)$$

where $F_0 = 1/2\pi RC$ and F_2 and F_1 are the upper and the lower frequency limits, respectively, being

omission of the grid leak in a conventional low-level amplifier, leaving only surface leakage paths between the grid and cathode, reduces the noise due to shot effect and thermal agitation. A cathode resistor of proper size gives further lowering of noise level

considered. It can be seen from Eq. (5) that the thermal agitation voltage output of an RC combination is independent of the value of R, because $F_1 = 0$ and $F_2 = F_0$, reducing from a function of R and C to a function of C only.

If the noise voltage from an RC combination is applied to an amplifier, some of this voltage may be in part of the frequency spectrum which is not passed by the amplifier. In this case, the voltage passed by the amplifier would be a function of R as expressed in Eq. (5), where F_1 and F_2 would now be the frequency limits of the amplifier, and C would be the grid leak and the input capacitance in the amplifier circuit. If F_1 is very much less than the upper frequency limit of the amplifier, Eq. (5) reduces to:

$$e = 1.28 \times 10^{-10} \sqrt{\frac{1}{2\pi C} \cot^{-1} \frac{F_1}{F_2}} \quad (6)$$

The form of Eq. (5) can be changed to show more clearly the relation between the thermal noise and the value of R.

$$= 1.28 \times 10^{-10} \sqrt{\frac{1}{2\pi C} (\tan^{-1} 2\pi F_2 CR - \tan^{-1} 2\pi F_1 CR)} \quad (5a)$$

$$\tan \left[\frac{2\pi C e^2}{(1.28 \times 10^{-10})^2} \right] = \frac{2\pi C (F_2 - F_1) R}{1 + 4\pi^2 F_1 F_2 C^2 R^2} \quad (5b)$$

Eq. 5(b) shows that the noise increases as the value of R increases from zero, reaches a maximum at some finite value of R, and decreases as the value of R is increased beyond this value. This equation shows that operation of a tube with an open grid would be less noisy than operation with a grid leak. In an amplifier circuit, to obtain minimum noise, the grid leak is sufficiently high if the thermal noise is less than the shot effect.

Another source of noise is the flow of leakage current between the cathode and the grid. This noise would be at a minimum when the cathode-to-grid voltage is at a minimum. Thus the tube would be quietest with a proper value of bias and it remains to be shown that the open grid tube automatically biases itself to that bias voltage.

To aid in determining the desirability of an open grid, a low noise level, wide-range amplifier was built. The first stage had a 6SJ7, triode-connected, with a gain of 11 db. The next two stages, using 6SJ7 tubes, had a gain of 68 db. The output stage, using a 6J5, was a cathode follower. The frequency response was down 6 db at 200 cy-

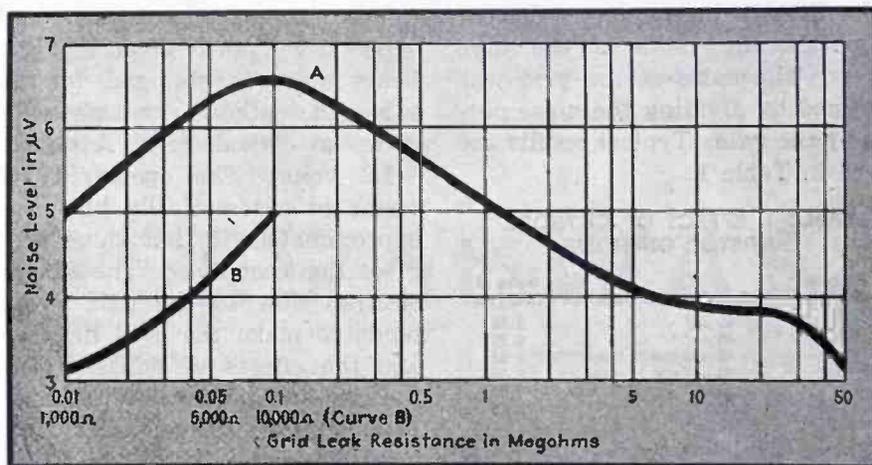


FIG. 2—Noise level vs. grid leak value for a triode-connected 6SJ7 tube. Curve B is for very low values of grid-cathode resistance

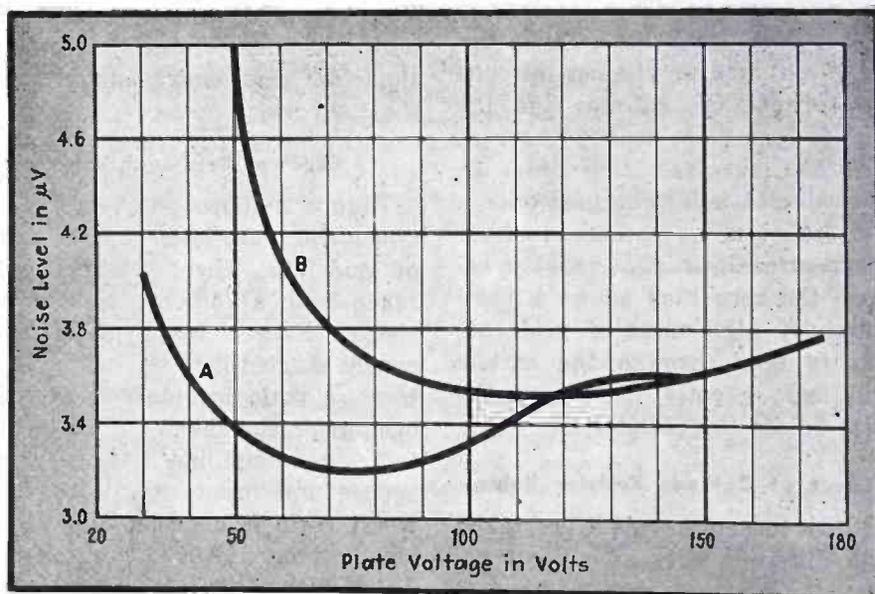


FIG. 3—Noise level vs. plate voltage for a triode-connected 6SJ7 tube with two different grid circuit arrangements. Curve A—40 µµf in grid circuit; curve B—40 µµf in parallel with 35 megohms in grid circuit

cles and at 200 kc. The entire amplifier was built in a copper box which gave excellent shielding. Because flicker noise is a low-frequency effect and not dependent upon the grid leak, a high-pass constant-K filter was placed at the output of the amplifier to suppress frequencies below about 650 cps and thus substantially eliminate the flicker effect.

Experiments With Open-Grid Tubes

The first tests were made with a cathode resistor alternately in and out of the first stage. A 40- μmf capacitor was used in the grid circuit to simulate the condition of an open-grid tube operating from a high-impedance crystal. For the next two measurements a 35-megohm resistor was put in parallel with the capacitor to give the condition of operation with a high-value grid leak. Finally, the grid was shorted to obtain the value of the tube noises. The noise at the grid was obtained by dividing the noise output by the gain. Typical results are given in Table 1.

TABLE 1. EFFECT OF CATHODE RESISTOR ON NOISE

Cathode Resistor	Grid Circuit Impedance	Noise at Grid (μv)
In	40 μmf	3.32
Out	40 μmf	4.26
In	40 μmf and 35 meg.	3.68
Out	40 μmf and 35 meg.	8.40
In	Short	3.00
Out	Short	3.69

These results show that the noise is less with an open grid than with a grid leak. In all three cases the noise is less with a cathode resistor than without one. This result is to be expected, for the cathode resistor voltage drop reduces the voltage between the cathode and the grid, reducing the leakage current and the noise resulting from it. The value of noise obtained with a grid leak and no cathode resistor is exceptionally high, probably because the zero bias allows a comparatively high value of grid current to flow through the carbon grid leak, greatly increasing the noise across the resistor.

Effect of Cathode Resistor Value

Noise measurements were taken with different sizes of cathode resistors. The test was made with 40 μmf in the grid circuit. The resulting curve of noise level vs. cathode voltage is not so important as

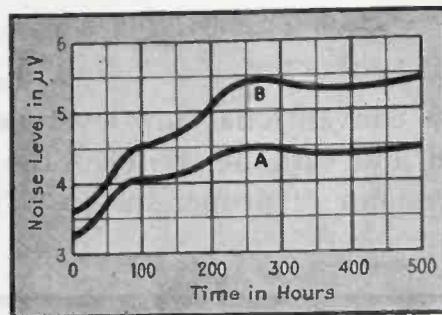


FIG. 4—Noise level vs. number of hours of continuous operation for a triode-connected 6SJ7 tube. Curve A—40 μmf in grid circuit; curve B—40 μmf in parallel with 35 meg in grid circuit

the curve of noise level vs. cathode-grid voltage. Since this voltage cannot be measured directly because any voltmeter would upset the circuit conditions, it was necessary to obtain a calibration curve of plate potential vs. grid voltage without a cathode resistor.

The curve of noise level vs. cathode-grid voltage is given in Fig. 1. Least noise is obtained for that value of cathode resistor which gives a cathode-grid voltage of -1.2 volts. The open-grid tube seems to automatically bias itself approximately to that value which gives the least noise. The effect of electron flow to the grid (which tends to make the grid negative) and the effects of emission from the grid and gas current to the grid (which tend to make the grid positive) balance each other to give the grid a small negative bias.

The foregoing test was repeated with a 35-megohm grid leak in addition to the 40- μmf capacitor. The minimum noise obtained was greater than the minimum noise without the grid leak.

Effect of Grid Leak Value

Figure 2 shows the relation between the noise level and the value of grid leak. These readings were taken with a 750-ohm cathode resistor. Except for a shorted or nearly shorted grid the best signal-to-noise ratio is obtained with an open grid. For the constants in this test, i.e., amplifier frequency response and input capacitance, the worst ratio is obtained for a grid leak around 100,000 ohms. For a different amplifier the worst ratio would occur at a different value of grid leak but the general shape of the curve would be the same. These

results are in agreement with Eq. 5(b) and the discussion following it.

Effect of Plate Voltage

The relation between the plate voltage on a tube and the noise level at the grid is given in Fig. 3. Again there is less noise without a grid leak than with a grid leak, but in both cases the best signal-to-noise ratio is obtained for a plate voltage of about 90 volts.

It would be expected from Eq. (1) that the noise would continue to decrease as the plate voltage is increased because the g_m is increasing. However, the larger number of positive ions and secondary electrons present in the tube at higher plate voltages tends to make the tube slightly noisier.

Effect of Temperature and Time

In various measurements it was noticed that the noise changed as the temperature of the tube changed, the noise in a cold tube being greater than the noise in a warm tube. This effect is undoubtedly due to leakage paths, which change as the tube is heated and become saturated when the tube is hot. The change in the noise level is just as great with a grid leak as without one, and thus the addition of a grid leak does not reduce the noise due to the random leakage paths. An attempt was made to reduce this transient effect by boiling the tube and its socket in wax, but this did not help nor did it reduce the noise level.

A long-time test was performed on five 6SJ7 tubes by continuously drawing plate current through the tubes and measuring the noise level at certain time intervals. Typical results are given in Fig. 4. It can be seen that the tubes have a general tendency to become noisier with age, but that in all cases, the noise is greater with a grid leak than without a grid leak. These tests show that tubes operated without a grid leak do not tend to become any more erratic than tubes operated with a grid leak.

Conclusions

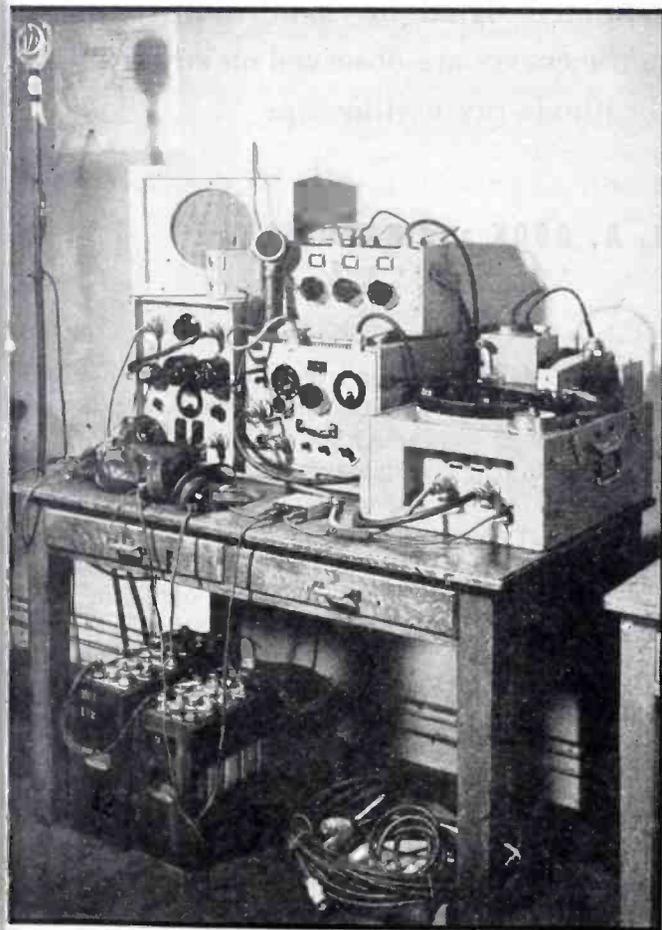
In the experiments performed, the noise level was always less without a grid leak than with one. In

(Continued on page 234)



Recording equipment developed by the British Broadcasting Corp. for use at the front is often housed in trucks of this type, which include living facilities, 200 yards of microphone cable, a shortwave receiver and a three-channel mixer

RECORDERS at WAR



RIGHT—Midget recorder developed by BBC weighs only 37 lb. Driven by a double-spring motor, it contains amplifier and batteries. Single knob turns amplifier on, starts turntable, and lowers piezo-electric cutter. Volume indication is by neon lamp. Disks are double-sided with three-minute playing time and 15 are carried. Fifteen seconds before the end of cut a warning light appears



LEFT—Closeup of 450-lb. recording equipment shows arrangement for use in a motor torpedo boat. Turntable at the right is powered by a 12-v d-c motor with friction drive. Speed-control rheostat works in conjunction with neon stroboscope run by a stable oscillator. High-sensitivity cutter-head has satisfactory response from 60 to 4500 cps. Pentodes are used in the first amplifier stages and in the output stage in push-pull while negative feedback keeps total harmonic content below one percent at normal recording level. Program-level meter operates from a diode rectifier and pentode amplifier. Motor-generator, driven by nickel-iron battery, provides plate voltages

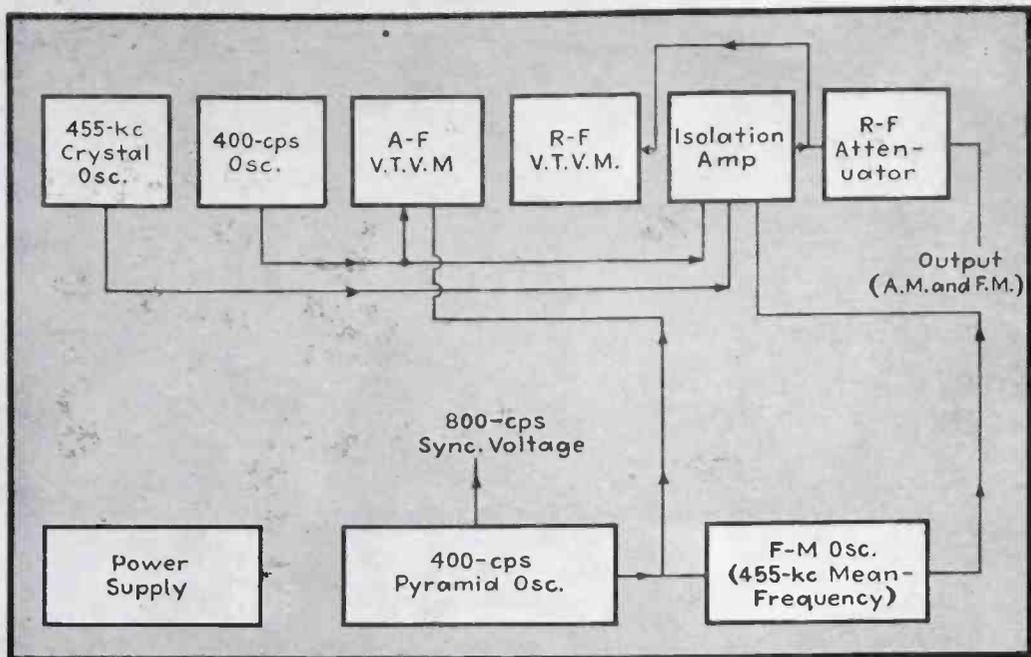


FIG. 1—Block diagram of the test unit, shown without switching. A complete schematic is given in Fig. 5

Visual Alignment of

ALIGNMENT of the wide-band i-f amplifiers in high-fidelity receivers on a production basis is a difficult operation. One common method involves the use of an amplitude-modulated signal generator and an output meter for sensitivity measurements, and a frequency-modulated signal generator in conjunction with a cathode-ray oscilloscope for band-width adjustments. Obviously, the adjustment and switching of several instruments introduces complications.

This paper describes a production test unit which greatly simplifies the job. It contains an a-m generator, an f-m generator, an isolation amplifier and an output attenuator common to both generators, an a-f vacuum-tube voltmeter and an r-f vacuum-tube voltmeter. It also provides synchronizing voltage for an external oscilloscope. A block diagram of the test unit, with switching omitted, is shown in Fig. 1.

A-M Signal Generator

The a-m signal generator consists of a 455-kc crystal-controlled 6SJ7 in a Colpitts circuit, driving a 6C5 cathode-follower type ampli-

Production test unit provides an amplitude-modulated signal for sensitivity measurements and a frequency-modulated signal for band-width adjustments. Response curves are observed on an external cathode-ray oscilloscope

By H. A. COOK and HAROLD MOSS

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fier which provides low-impedance output. With a reasonably active crystal, about 400 cycles of frequency adjustment may be obtained by varying the tuned-circuit constants. Temperature control of the crystal is unnecessary.

The a-m generator is modulated in the grid circuit of the separator tube. The modulator, which operates at 400 cps, is of the R-C type shown in Fig. 2 and its frequency is given by the expression

$$f = 1/(2\pi\sqrt{C_1C_2R_1R_2})$$

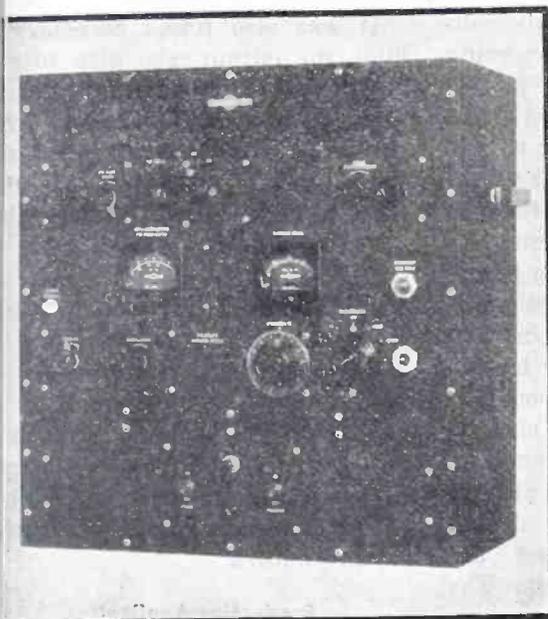
This circuit provides an excellent source of sinusoidal audio frequency.

Improved stability of oscillation results when a ballast resistor of some kind, rather than an ordinary resistor, is placed at R_2 . A 3-watt 110-volt lamp seems satisfactory.

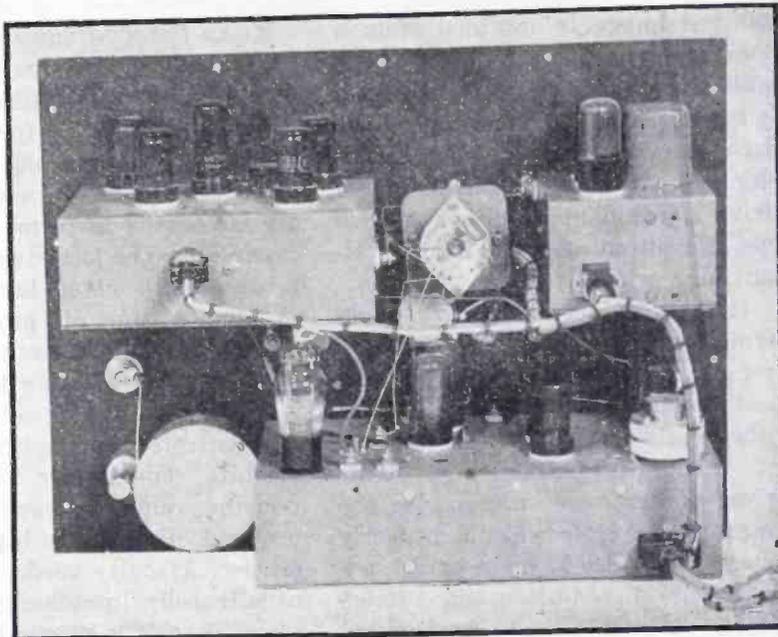
F-M Signal Generator

While the R-C oscillator circuit of Fig. 2 is ordinarily used at audio frequencies, it is equally adaptable to radio frequencies.¹

From the expression for frequency of oscillation given above, it is apparent that a variation of R_1 , R_2 , C_1 or C_2 will result in a variation in frequency. By substituting the plate resistance of a vacuum tube for either R_1 or R_2 and varying



The production test unit. A cathode-ray oscilloscope is used externally



Back view of the test unit, with the bottom section (containing the power supply) removed

Wide-Band I-F Amplifiers

the grid voltage at an audio rate, frequency modulation will result. A logical choice indicated the section of R_2 as the variable element, since it had one end at ground potential.

In order to obtain practical values for R_1 , R_2 , C_1 and C_2 at 455 kc, the cathode-follower circuit was used for R_2 in the actual circuit. Varying the grid voltage in the cathode-follower stage then varies the frequency of oscillation. Figure 3 indicates the variation in frequency

obtained as the grid potential of the variable-resistance tube serving as R_2 is varied. As may be seen, frequency excursions of 80 kc are possible with a four-volt peak audio signal.

An ordinary resistor, rather than a ballast resistor, is used at R_3 . A ballast resistor does not operate satisfactorily at R_3 at the higher frequencies, although an improvement in wave form results. At 455 kc, the ballast resistor swings constantly, seeking equilibrium, which

shifts the mean-frequency several kilocycles. This objectional effect is not important at audio frequencies.

A 6SN7 connected as a multivibrator operating at 400 cps supplies about 50 volts to a 6SJ7 clipper circuit.² The output of the clipper circuit is a pyramid wave, extremely sharp at the corners and nearly straight sided. It proved wise to adjust the constants of the multivibrator until the resultant square-wave pulses were of equal lengths, as this affects the symmetry of the pyramid. A slight curvature still remaining on one pyramid slope is due to loading of the multivibrator on one side only; however, this is minor and of little consequence. About 4.9 volts peak is available at the output, the wave form of which is shown at Fig. 4.

Connection of the pyramid wave to the modulating grid of the resistor tube constituting R_2 causes frequency modulation linear with time; that is, the rate of change is constant across the entire excursion.

Oscilloscope Synchronization

The necessary double frequency to properly synchronize the double-

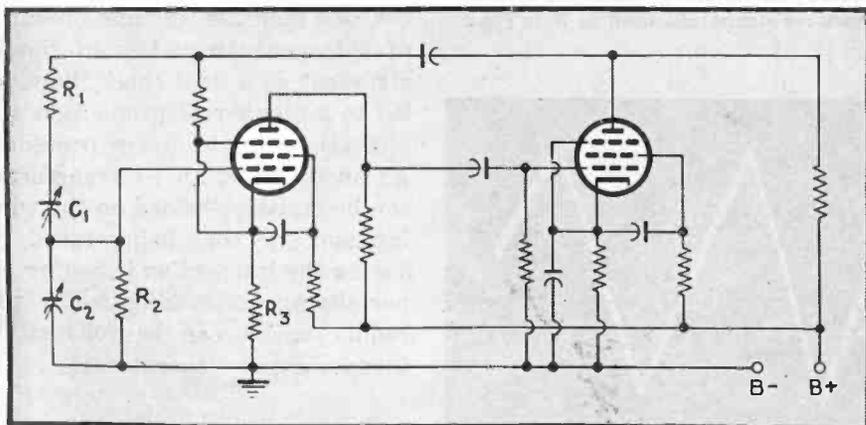


FIG. 2—Simplified schematic showing the type of R-C oscillator circuit used to obtain 400-cps modulation of the 455-kc amplitude-modulated signal generator. A similar R-C circuit is used as the frequency-modulated signal generator

humped image is obtained from a point common to both plates of the multivibrator, which supplies a pulse on each half of the square wave, serving as a frequency doubler. About 2 volts is available to drive a resonant amplifier at 800 cps, the output of which is an excellent sine wave.

It proved necessary to supply synchronizing pulses in this manner because of the tendency of the oscilloscope sweep to "pull" on every other cycle if the pulse is supplied at modulating frequency. This gives an erroneous pattern, as the uncontrolled cycle will not properly overlap, and leads to incorrect adjustment. In addition, the oscilloscopes available had interlocking controls. Also, when they were supplied with a square synchronizing pulse the sweep would trigger at times difficult to control, making it very hard to center the image.

The use of a sine wave, making it possible to adjust the triggering time of the sweep circuits along an even slope, plus the incorporation of a phase-shift network ahead of the sync output, makes it possible to obtain smooth adjustment of the position of the image. About 80 degrees phase shift is available at the grid of the sync output section of the 6SN7, using an *R-C* network with $R = X_c$. This, plus the apparent phase shifts possible by adjustment of the oscilloscope-sweep triggering level, permits positioning of the trace without the usual jockeying of controls. About 6 volts rms at 800 cycles is obtained from the sync output, reducing to about 4 at maximum phase shift.

An 800-cps amplifier incorporated in the test unit utilizes a toroid coil with a good *Q* (about 45 at 1000 cps), and an inductance of about 169 mh, those being the values available in toroids of small sizes.

The value of double-frequency sine-wave synchronization has been demonstrated in the ease with which oscilloscope positioning is obtained during production tests.

Other Circuit Details

The precision slide-wire attenuator common to both signal generators is directly calibrated in microvolts. Maximum f-m and a-m output values are greater than two volts, developed across 500 ohms.

The a-f and r-f vacuum-tube volt-meters are of the same type, being peak reading and calibrated in rms values. Some wave form error is caused by the pyramid, but this is of no consequence since these values are calibrated in terms of the f-m excursion. The latter was found on a band-width meter, but can be approximated for all practical purposes by the shift attained in variation of the resistance tube bias.

The incorporation of a sensitivity control in both vtvm circuits permits considerable tolerance in resistor values, always a difficult problem. Due to the highly degenerative circuit used, tubes are usually fully interchangeable. The two-volt scale is nearly linear.

The power supply unit is conventional in design. Voltage-regulator tubes were employed to aid in stabilizing the f-m oscillator, which proved somewhat critical of supply voltage.

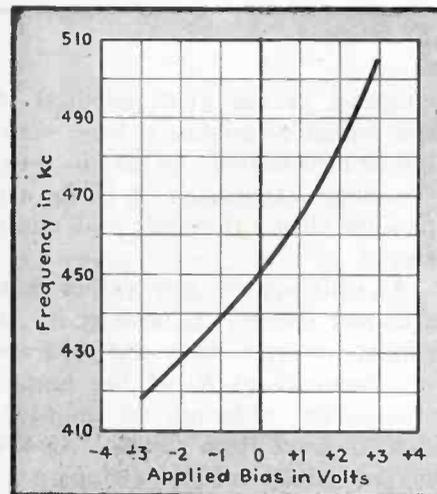


FIG. 3—Variation in f-m oscillator frequency around the 455-kc mean-frequency obtainable by changing the bias on a resistance-tube used as *R*, in Fig. 2

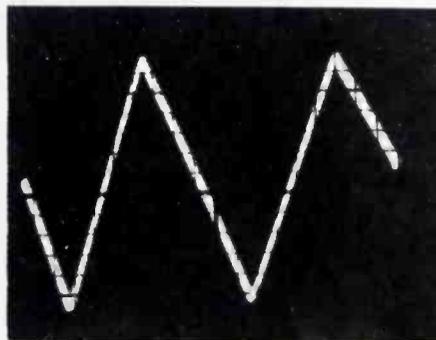


FIG. 4—Output wave form of the 400-cps pyramid oscillator used to modulate the f-m signal generator

It was also found necessary to filter the output-tube bias to prevent 120-cycle modulation. This is accomplished with a simple *R-C* circuit. The available bias is quite constant, staying within 5 percent in spite of a load variation of better than 2:1.

The complete circuit schematic for this test unit is shown in Fig. 5, with component values suitable for 455-k operation. Care must be taken to prevent interaction between circuits and the leakage of extraneous signals into the output. Adequate shielding and careful layout will tend to minimize all trouble of this nature.

Production Application

When using the equipment for production alignment of receivers a preliminary alignment is usually first made on amplitude modulation, adjusting the i-f amplifier to maximum output and taking a reading of overall sensitivity. At this point, sets showing insufficient gain are diverted to the repair lines.

The generator is then switched to f-m output and adjusted to 455 kc mean frequency. The sweep is adjusted to superimpose the traces. It is now possible to make the corrections in i-f tuning for symmetry and width of the "nose" of the trace. The wide excursion of frequency available permits examination of any stage with a simple adjustment of the band-width control.

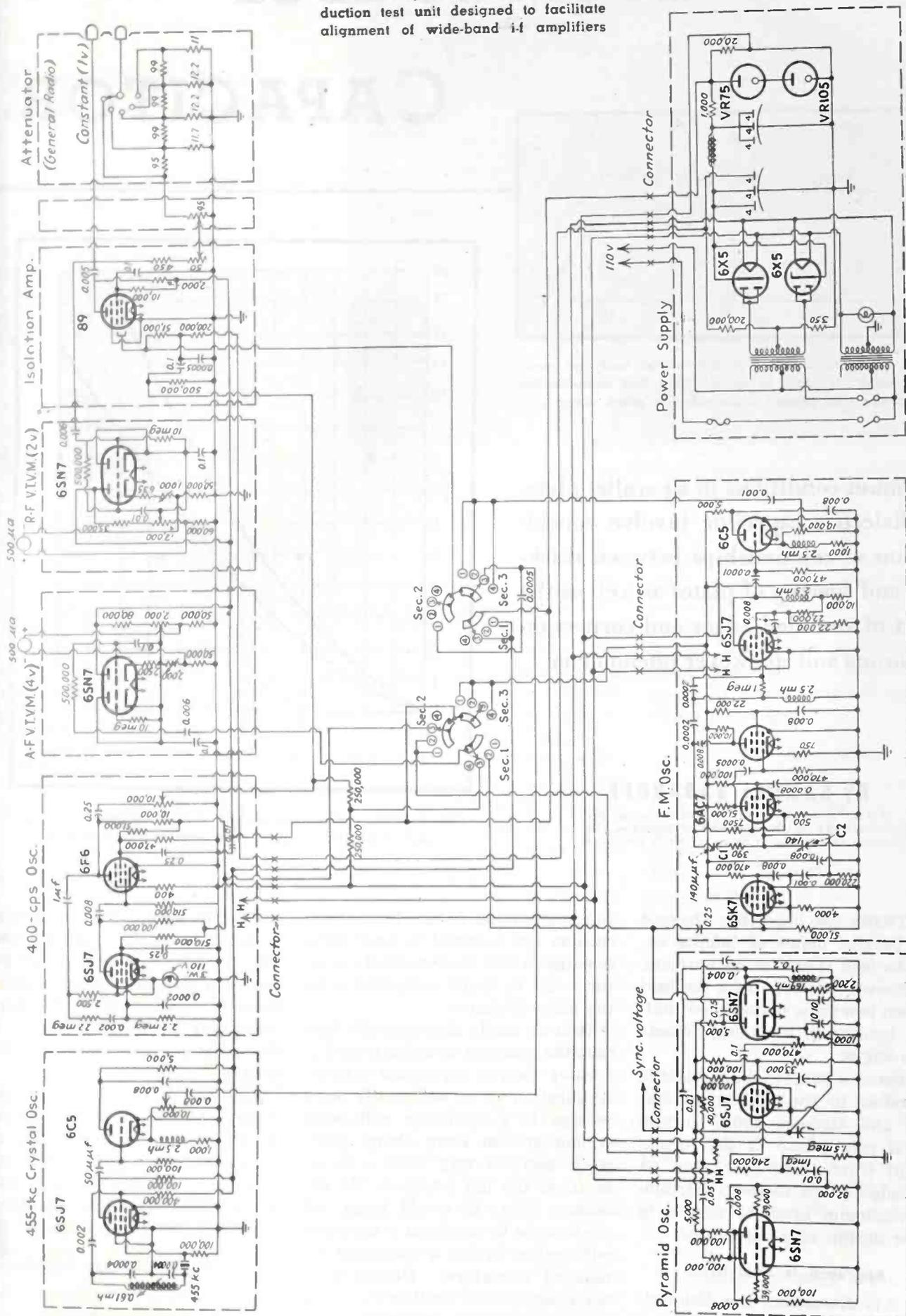
The final check is made with a-m output as the above procedure reduces the overall sensitivity by a small amount. F-M alignment is not an end in itself, due to the many variables encountered.

A well-trained operator is, of course, required in the operation of this generator. Use of the instrument as a final check, however, led to a number of production simplifications in alignment procedure. As an example, an i-f transformer can be resistive-loaded on the winding opposite that being tuned, reducing the interaction in tuning and permitting an adjustment procedure which can be followed by inexperienced operators.

REFERENCES

- (1) Chang, C. K., F-M Resistance-Capacitance Oscillator, *Proc. IRE*, Jan. 1948.
- (2) Mayer, H. F., Visual Alignment Generator, *ELECTRONICS*, April 1940.

FIG. 5—Complete schematic of the production test unit designed to facilitate alignment of wide-band i-f amplifiers



ROUNDED-EDGE

CAPACITOR

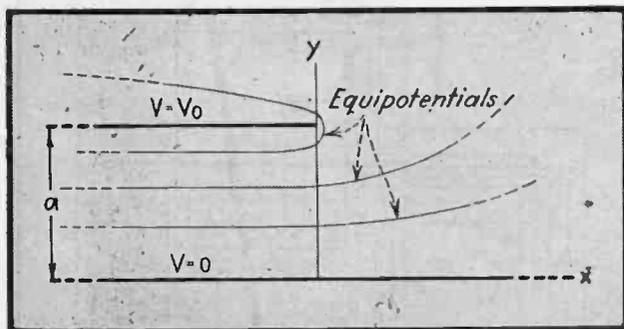


FIG. 1—Situation adjacent to one infinite and one semi-infinite capacitor plate in space. Note that equipotential contours tend toward a curved-edge plate, above

Optimum conditions in a parallel-plate, air-dielectric capacitor involve consideration of relationships between thickness and spacing of plates as well as the effect of rounded edges and corners on corona and sparkover phenomena

By **SAMUEL SABAROFF**

WOAU Broadcasting Co., Philadelphia, Pa., Consultant to Barker and Williamson, for whom this material was originally prepared.

BETWEEN two oppositely charged parallel plates of infinite extent the field is said to be uniform. It is known, however, that the field between two finite plates is *not* uniform, tending to greater gradients at the edges.

Stress at a point in a dielectric is determined by the gradient at that point and stresses above certain critical values lead to the formation of corona and sparkover. A knowledge of the factors determining maximum gradient assists in proper design of a capacitor.

Approach is Analytical

In this discussion, the dielectric will be taken as air. Plate thickness is assumed to be small, compared to any other linear dimension, except

where otherwise noted. Plates with corners are assumed to have them rounded so that their radii of curvature will be large compared with the plate thickness.

It is an easily demonstrable fact that the gradient at a sharp edge is greater than at a rounded surface. Application of a sufficiently high voltage to a conductor will make corona stream from sharp edges while there is very little evidence of it on the flat surfaces. At the outset, then, it would seem advantageous to construct a capacitor with edges having a maximum radius of curvature. Disregarding the possibility of curling the edges over to increase curvature, the plates should be as thick as possible up to a certain point. This les-

sens the gradient at the edges.

Now suppose the spacing between the two plates is very small compared to plate thickness. For sufficiently small spacing, breakdown will occur between the plates and the edge effect becomes relatively minor.

In view of these considerations it appears that there may be a relation between plate spacing and thickness which will give a minimum gradient for a fixed voltage and a given plate spacing. This is the basic design problem.

Spacing-Thickness Relation

This may be pictured as follows with plate spacing identified as S and thickness as T . For large values of S/T the radius of the plate edge

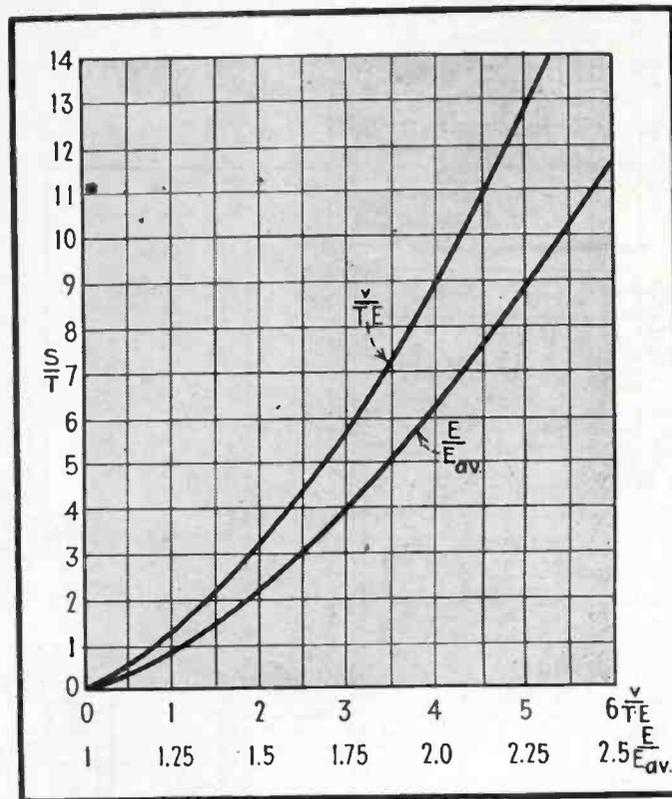


FIG. 2—Values of capacitor-plate spacing-thickness ratio are plotted against potential and gradient relationships

PLATES

small and a high gradient exists here. As plate thickness is increased—keeping plate center-to-center spacing and applied voltage constant—the radius of edge curvature is increased. This decreases the edge gradient. Inside the capacitor, however, the gradient increases because of the reduced spacing. The best value of S/T can be located at the crossover point between these two opposing effects. At this point the maximum gradient that can occur becomes a minimum. Such critical values have been calculated and observed for other electrode shapes.¹

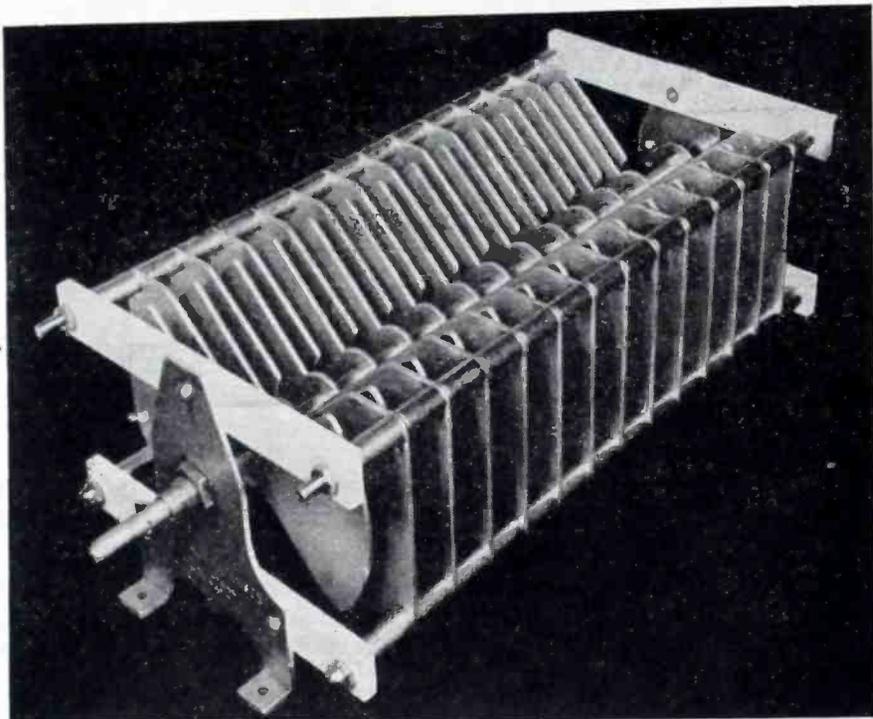
It has been suggested by Ekstrand² that the best value of S/T may be between the values of 2 and 3. This investigation seems to corroborate his figures by fixing the optimum S/T at 2.77.

What Constitutes Breakdown?

Let us now consider some factors having to do with capacitor breakdown. It has become somewhat of a habit to consider breakdown as coincidental with sparkover. Actually breakdown has occurred at the first sign of corona, and corona may become evident at considerably lower voltage than sparkover.

When a conductor is raised beyond a certain critical potential, the air adjacent to it becomes ionized, forming corona. The ionized air, being itself a conductor, can be considered to increase the size of the original conductor. If this effect is accompanied by an increase of gradient, the condition becomes unstable and sparkover occurs. If there is a decrease in gradient, the condition is stable and corona remains as such.

Application of this concept to our capacitor is almost obvious. Suppose that S/T is greater than the



Rounded edges are a corona and sparkover-resistant feature of this Barker and Williamson capacitor. Type is similar to those discussed in the text

critical value. Now, as we apply a gradually increasing voltage, corona will commence. If we consider the corona as part of the plate, then in effect the plate thickness has been increased, thus reducing the value of S/T . Sparkover should then take place when the value of S/T is less than the optimum.

If we start applying voltage when S/T is less than the best value, then the transition from corona to sparkover is almost instantaneous since an increase in plate thickness will increase the gradient. Of course, there are irregularities in the practical manifestation of this principle. One reason is that corona will not form uniformly on the plates, being most evident where the gradient is maximum.

It has been found that in the case of wires, spheres, and concentric cylinders³, corona appears for a constant gradient at a distance proportional to \sqrt{r} from the surface, where r is the radius. It may therefore be expected that experiment will show the existence of a similar factor in the formation of corona at the edges of a capacitor.

The microcosmic picture of air breakdown is complex and even of a somewhat metaphysical nature⁴ but breakdown characteristics have, in general, been determined by experiment.

This discussion concerns, in the main, a calculation for the best value of S/T . Note that the derivations and approximations are guided by existing physical conditions. Results must inevitably be tested by experiment and qualified where necessary.

Basic Assumptions

Assume that the plates are semi-infinite in extent and that the radius of curvature of an edge is equal to half the plate thickness. Because of symmetry, thus applying the theory of images, it only will be necessary to consider the field between one semi-infinite plate and an infinite plate. This latter is placed midway between the semi-infinite plates and has a potential equal to half their sum.

First, however, consider a pair of plates that are of extreme thinness. The solution for this case is well known.⁵ An approximate plot of the equipotentials is shown in Fig. 1, in which it is assumed that the semi-infinite plate has a potential of V_0 volts with respect to the infinite plate and is spaced a inches from it.

Notice particularly the trend in the shape of the equipotentials as they approach the semi-infinite plate. Any equipotential can be replaced by a conductor (of the same

TABLE I. PLATE-DIMENSION RATIOS AND VOLTAGES OF CAPACITORS AT VARIOUS FREQUENCIES

T in.	S in.	S T	Sparkover kv			Max. gradient (calculated) kv/in.		
			60 cps	700 kc	1500 kc	60 cps	700 kc	1500 kc
0.128	0.218	1.705	14.0	13.5	13.7	89.1	85.8	87.1
0.04	0.192	4.8	8.4	7.59	6.82	80.2	72.5	65.1
0.064	0.719	11.24	24.0	14.28	11.7	82.0	48.8	40.0

shape and charged to the same potential) without disturbing the external field in any way. Thus, if the equipotentials are replaced by equivalent plates, they will tend to an ordinary thin plate with rounded edges as the potential of the semi-infinite plate is approached. The procedure will now be to match, as far as possible, an actual plate to one of these equipotentials and thus obtain an expression for the maximum gradient at its edge. A somewhat arbitrary extension will then be made to indicate the maximum gradient on a plate of any thickness.

Potential around an infinitely thin plate, semi-infinite in extent, can be expressed in the following parametric form

$$\begin{aligned} x &= \frac{a}{\pi} \left[1 + e^{-\pi U/V_0} \cos(\pi V/V_0) - \pi U/V_0 \right] \\ y &= \frac{a}{\pi} \left[e^{-\pi U/V_0} \sin(\pi V/V_0) - \pi V/V_0 \right] \end{aligned} \quad (1)$$

where V is potential at any point having the coordinates xy . U is the force or stream function.

In complex form Eq. (1) is

$$Z = \frac{a}{\pi} \left(1 + e^{j\pi W/V_0} + j\pi W/V_0 \right) \quad (2)$$

where $Z = x + jy$, $W = V + jU$, and $j = \sqrt{-1}$.

Finding the Gradient

At any point the gradient is found by

$$E = \left| \frac{dw}{dz} \right| = \frac{V_0/a}{\sqrt{1 + e^{-2\pi U/V_0} + 2e^{-\pi U/V_0} \cos(\pi V/V_0)}} \quad (3)$$

where E is gradient in volts per inch.

Along an equipotential, the gradient will depend entirely on concentration of the lines of force. In order to find the point of maximum gradient for any potential, it will

be necessary to maximize E partially with respect to force function U . Thus $\delta E/\delta U = 0$ when

$$e^{-\pi U/V_0} = \cos \left[\pi (V_0 - V)/V_0 \right] \quad (4)$$

Substituting Eq. (4) in (1) and (3)

$$\begin{aligned} x_m &= \frac{a}{\pi} \left\{ \sin^2 \left[\pi (V_0 - V)/V_0 \right] \right. \\ &\quad \left. + \log \cos \left[\pi (V_0 - V)/V_0 \right] \right\} \\ y_m &= \frac{a}{\pi} \left\{ \pi V/V_0 + \sin \left[\pi (V_0 - V)/V_0 \right] \right. \\ &\quad \left. \cos \left[\pi (V_0 - V)/V_0 \right] \right\} \end{aligned} \quad (5)$$

and

$$E_m = \frac{V_0/a}{\sin \left[\pi (V_0 - V)/V_0 \right]} \quad (6)$$

As V approaches V_0 , Eq. (5) and (6) become

$$\begin{aligned} x_m &= \frac{a \pi (V_0 - V)^2}{2 V_0^2} \\ y_m &= a \end{aligned} \quad (7)$$

and

$$E_m = \frac{V_0^2}{a \pi (V_0 - V)} \quad (8)$$

Selecting the Curvature

At this point it becomes necessary to determine the manner in which an actual plate should be matched to an equipotential. A reasonable condition is that the radius of curvature of the actual plate and the radius of curvature of the equipotential at the point of maximum gradient be made equal.

For the radius of curvature the formula is

$$R = \left[1 + \left(\frac{dy}{dx} \right)^2 \right]^{3/2} \left(\frac{d^2y}{dx^2} \right)^{-1} \quad (9)$$

At any point on an equipotential the radius of curvature, as found from Eq. (1) and (9), is

$$R = \frac{a \left[1 + 2e^{-\pi U/V_0} \cos(\pi V/V_0) + e^{-2\pi U/V_0} \right]^{3/2}}{\pi e^{-\pi U/V_0} \sin(\pi V/V_0)} \quad (10)$$

On any equipotential, at the point

of maximum gradient, the radius of curvature is found by substituting Eq. (4) in (10), thus

$$R_m = \frac{a \sin^2 \left[\pi (V_0 - V)/V_0 \right]}{\pi \cos \left[\pi (V_0 - V)/V_0 \right]} \quad (11)$$

As V approaches V_0 , the radius of curvature becomes

$$R_m = a \pi (V_0 - V)^2 / V_0^2 \quad (12)$$

Let S equal the actual plate spacing and T equal the plate thickness. An approximate match can be assumed when $(y_m - R_m)$ is identified with $S/2$ and R_m is assumed equal to $T/2$. It is not necessary to consider x_m and it is now ignored. V is made equal to $v/2$ where v is the actual potential between the plates. When a and V_0 are eliminated from Eq. (7), (8) and (12),

$$S = \frac{v}{E} \left(\frac{v}{\pi ET} + \frac{2}{\pi} \right) - \frac{T(\pi - 1)}{\pi} \quad (13)$$

where the subscript has been omitted from E_m .

Since T is assumed small with respect to S , the right-hand term can be omitted in Eq. (13), resulting finally in

$$S = \frac{v}{E} \left(\frac{v}{\pi ET} + \frac{2}{\pi} \right) \quad (14)$$

Up to this point a small value of T has been assumed with respect to S . Now disregard the derivation and consider Eq. (14) alone. If we allow the plate thickness to approach infinity in Eq. (14), it becomes

$$S = \frac{2}{\pi} \frac{v}{E} \quad (15)$$

Compare this with the relation

$$S = \frac{v}{E} \quad (16)$$

which holds for two plates in which the edge effect is negligible. This is equivalent to the condition when T equals infinity.

Condition Generalized

Similarity between Eq. (15) and (16) suggests the possibility of Eq. (14) being adjusted so that it would hold for T large as well as small. This can be done approximately by replacing the constant $2/\pi$ in Eq. (14) by unity, thus

$$S = \frac{v}{E} \left(\frac{v}{\pi ET} + 1 \right) \quad (17)$$

Eq. (17) is admittedly approximate. Assuming for the moment that its accuracy has been established, let us examine it for the presence of a best value for S/T . This best value is, of course, the

(Continued on page 268)

CATHODE FOLLOWER Calculations

Equations relating cathode follower output impedance to the value of the cathode resistor, the plate load resistance of the cathode follower tube, and the transconductance of the tube

By **HUMBERT P. PACINI**

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SOLVING for the output impedance of a cathode follower as the one shown in Fig. 1(a) is most convenient to set up the required circuit equations by assuming the cathode of the tube driven by a generator of voltage E_1 and internal resistance R_1 . Fig. 1(b) shows the addition of this generator and Fig. 1(c) is the resulting equivalent circuit.

The general equations for a two-loop network are*

$$Z_{11}I_1 + Z_{12}I_2 = E_1 \quad (1)$$

$$Z_{12}I_1 + Z_{22}I_2 = E_2 \quad (2)$$

where Z_{11} is the total impedance in loop 1, Z_{22} is the total impedance in loop 2, Z_{12} is the mutual impedance between loops 1 and 2, and E_1 and E_2 are the generator voltages in loops 1 and 2 respectively.

According to Fig. 1(c) the equivalent voltage acting in the grid circuit, or the rise in voltage from cathode to grid, is $(I_2 - I_1)R_2$, and $-\mu(I_2 - I_1)R_2$ is the voltage acting in the plate circuit in the direction

shown if it is taken as voltage driving I_2 clockwise. Upon substitution of these values in Eq. (1) and (2) there results

$$(R_1 + R_2)I_1 - R_2I_2 = E_1 \quad (3)$$

$$-R_2I_1 + (R_2 + R_p)I_2 = -\mu(I_2 - I_1)R_2 \quad (4)$$

Solving these two simultaneous equations yields for the driving point impedance

$$Z_1 = R_1 + R_2 - \frac{R_2^2(1 + \mu)}{R_p + (1 + \mu)R_2} \quad (5)$$

from which it is obvious that the impedance looking into the cathode; that is, the output impedance of the cathode follower, is

$$Z_1 - R_1 = R_2 - \frac{R_2^2(1 + \mu)}{R_p + (1 + \mu)R_2} = Z_{out} \quad (7)$$

Since μ is much larger than 1, especially in high-gain triodes and pentodes, Eq. (7) may be converted to

$$Z_{out} = R_2 - \frac{R_2^2}{(R_p/\mu) + R_2} = R_2 - \frac{R_2^2}{(1/g_m) + R_2} \quad (8)$$

This impedance is made up of the cathode resistance and the internal

impedance of the cathode in parallel; and if Z_c represents the latter, Eq. (8) can be written

$$Z_{out} = \frac{Z_c R_2}{Z_c + R_2} \quad (9)$$

After transformation and substitution of Eq. (8) for Z_{out}

$$Z_c = [(1 + g_m R_2)/g_m] - R_2 = 1/g_m \quad (10)$$

If the cathode follower tube had been used with a plate load, either to limit the plate current or to provide a push-pull voltage, the equation for the internal impedance of the cathode follower would be

$$Z_c = (1/g_m) + (Z_L/\mu) \quad (11)$$

where Z_L is the plate load.

The internal impedance of a cathode follower is given by Eq. (10) for the case of no plate load, or by Eq. (11) if there is plate load. It is seen from Eq. (9) that the effect of the internal impedance of the cathode follower tube is to add an impedance Z_c , in parallel with the cathode load impedance.

* Everitt, W. L., "Communication Engineering", McGraw-Hill Book Co., p. 217-229.

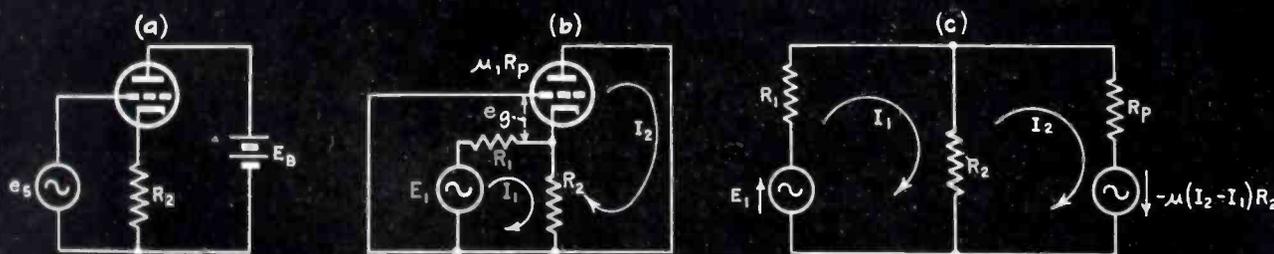


FIG. 1—(a) The actual circuit in which the impedance across R_2 is sought. In (b) a fictitious generator, E_1 , of internal impedance R_1 , is introduced. The equivalent circuit from which the derivation begins is shown at (c)

Circuit Response to NON-SINUSOIDAL

Short-cut method of determining the current response either graphically or analytically in circuits energized by square, saw-tooth, repeated exponential and similar waves, by decomposing into components starting at different instants, then adding response

FOURIER'S analysis¹ is a general method for evaluating the circuit response to non-sinusoidal periodic waves. But it is not always the most convenient method for evaluating the transient response, especially to those non-sinusoidal periodic waves which are discontinuous in the wave itself or its derivative with respect to time. The actual solution of a problem by means of this method is sometimes tedious and time-consuming.

Another method, possibly first used by Poisson and later by Duhamel² and based on the superposition of step functions, decomposes

¹ Based on a paper presented before the Chinese Institute of Engineers, American Section, in New York City July 2, 1944.

any kind of waves, periodic or not, into so-called Heaviside unit functions³ which start at different instants. This method has been used more extensively in treating non-periodic waves. In fact, it is a very powerful tool for evaluating the circuit response to some types of commonly encountered non-sinusoidal waves which are discontinuous in the wave itself or its derivative with respect to time, such as square waves, saw-tooth waves, trapezoidal waves, repeated exponential waves and output voltage waves of controlled rectifiers.

Owing to the geometry of the non-sinusoidal wave, an easier solution can often be obtained; instead of being decomposed into

Heaviside unit functions, the wave can be decomposed into waves of other types which have the same wave form but start at different instants. This short-cut method (based on an extension of "superposition of step function," generally known as Duhamel's integral) permits determining the transient response easily by either analytical or graphical methods.

Decomposition of Square Waves

Square waves are used in the communications field for testing the frequency response of electric circuits⁴. A symmetrical square wave having an amplitude A and a period of $2t_1$ can be decomposed into a number of different constant-ampli-

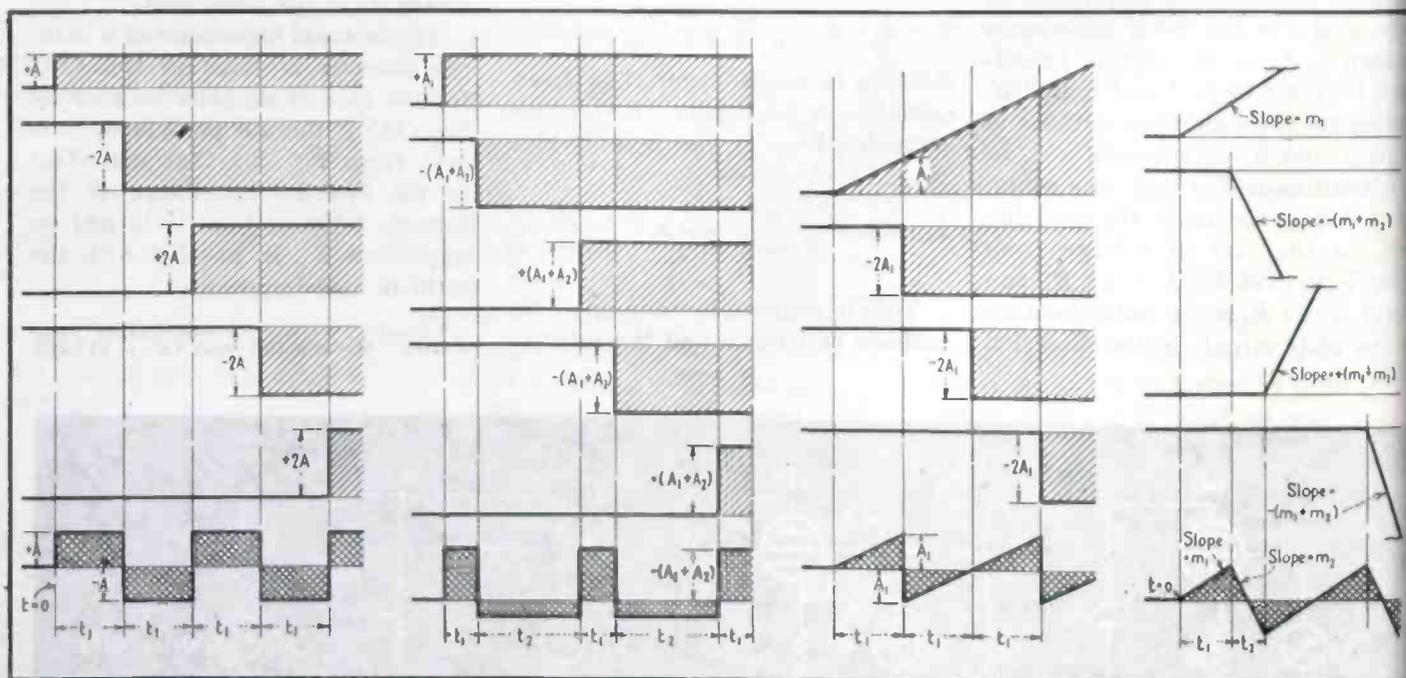


FIG. 1—Decomposition of symmetrical square waves shown at bottom with double shading

FIG. 2—Decomposition of unsymmetrical square wave into components shown above

FIG. 3—Decomposition of ideal saw-tooth wave into two types of components

FIG. 4—Decomposition of saw-tooth wave into rising and falling components

WAVE FORMS

By P. T. CHIN

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components starting at different time intervals, as shown graphically in Fig. 1. The first component starts at $t = 0$ and has an amplitude of $+A$. The second starts later and has an amplitude of $+2A$. At interval t_1 after this, the third component starts with an amplitude of $+2A$. Thereafter, components of $-2A$ and $+2A$ in amplitude start alternately at successive intervals of t_1 .

The decomposition of an unsymmetrical square wave, having unequal positive and negative amplitudes of A_1 and A_2 respectively, is shown in Fig. 2. The duration of A_1 is t_1 , and that of A_2 is t_2 .

Saw-Tooth and Trapezoidal Waves

Saw-tooth waves can also be used to test frequency response of electrical circuits. In some respects, these waves are superior to square waves, as suggested by Waidelech.⁵ An ideal saw-tooth wave, having a

slope A_1/t_1 and a period of $2t_1$, can be decomposed into a linearly rising voltage having a slope of A_1/t_1 and starting to occur at $t = 0$, plus constant driving forces of $-2A_1$ starting to occur at succeeding intervals of t_1 , as shown in Fig. 3.

The saw-tooth waves of Fig. 3 can hardly be produced by practical means, since it takes some time for the saw-tooth wave to fly back to its original position. Figure 4 shows more practical saw-tooth waves which can be produced by some electronic circuits.⁶ These waves can be decomposed into: A linearly rising wave of slope m , starting at $t = 0$; a linearly rising wave of slope $-(m_1 + m_2)$ starting t_1 later; a wave of slope $+(m_1 + m_2)$ starting at $t_1 + t_2$; a wave of slope $-(m_1 + m_2)$ starting at $2t_1 + t_2$, etc. (The linearly rising waves in Fig. 4 should continue to rise, but in order to save space they are not shown beyond the broken lines.)

Figure 5 shows the decomposition of trapezoidal waves. The procedure is more or less similar to that for saw-tooth waves.

Output Voltage Waves of Gaseous Rectifiers

When gaseous-discharge type rectifiers, such as thyratrons and ignitrons, supply an inductive load with continuous conduction of current, the geometry of the output voltage wave depends on the number of phases of the rectifier circuit and the angle of phase retard.⁸

Figure 6 shows the decomposition of the output voltage wave of a bi-phase uncontrolled rectifier circuit having no phase retard. It can be decomposed into a continuous sine wave having a peak value A_1 , starting in a positive direction at $t = 0$, followed by a series of sine waves each having a peak value of $2A_1$, and starting in a positive direction every half-cycle later.

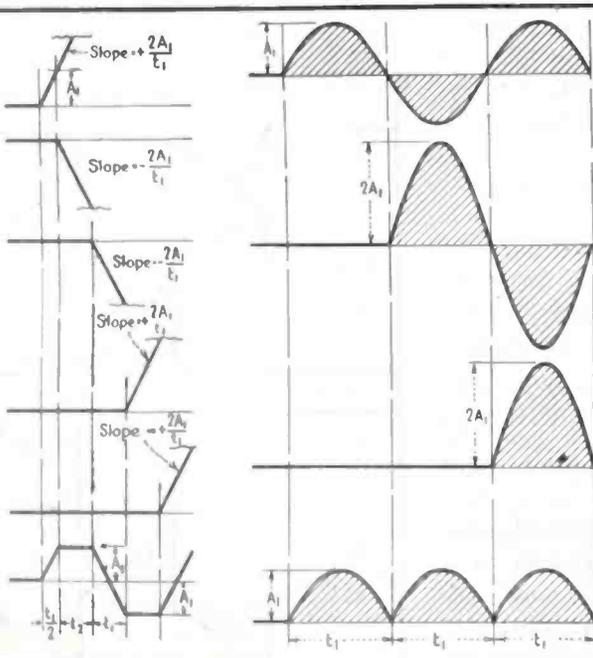


FIG. 5—Decomposition of trapezoidal waves. Components are cut off here to conserve space

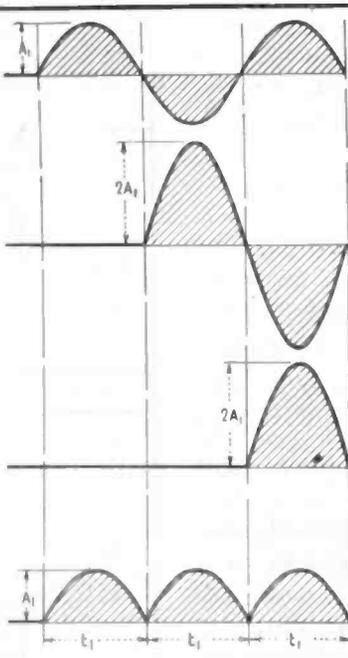


FIG. 6—Decomposition of output voltage of bi-phase uncontrolled rectifier; no phase retard

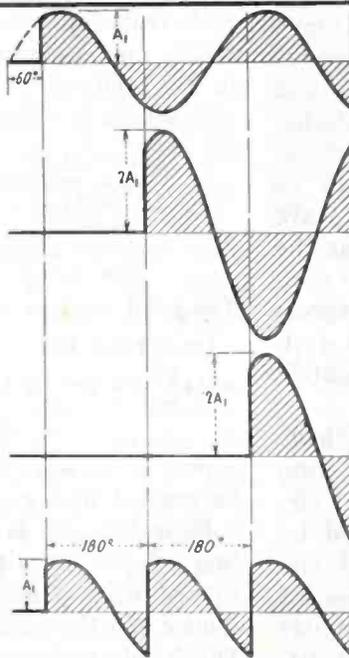


FIG. 7—Decomposition of output voltage of bi-phase rectifier, phase retarded 60 degrees

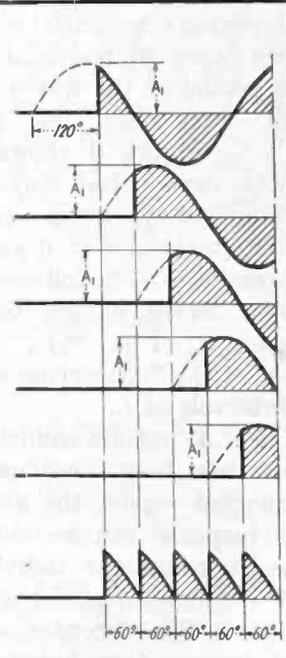


FIG. 8—Decomposition of output voltage of six-phase rectifier, phase retarded 60 degrees

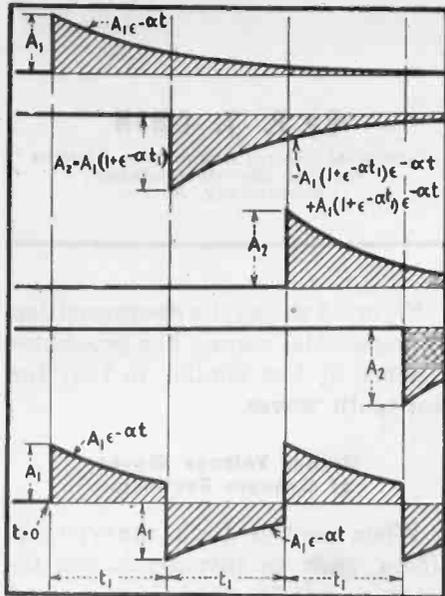


FIG. 9—Decomposition of repeated exponential waves

Figure 7 shows the decomposition of the output voltage wave of a bi-phase rectifier with a phase retard of 60 electrical degrees. It is evident that the decomposition is similar to that shown in Fig. 6 except that each sine wave starts with a magnitude corresponding to the value $A_1 \sin 60^\circ$ instead of zero.

Figure 8 shows the decomposition of the output voltage wave of a 6-phase rectifier. The continuous sine waves are spaced at 60° and all the sine waves have the same peak value A_1 .

Repeated Exponential Waves

Repeated exponential waves sometimes occur in television circuits. The period of the waves is $2t_1$ and each wave has the expression $A_1 e^{-at}$. Figure 9 shows that repeated exponential waves can be decomposed into a exponential wave which starts at $t = 0$ and has the expression $A_1 e^{-at}$, followed by component waves having the expressions $-A_1(1 + e^{-at_1})e^{-at}$ and $+A_1(1 + e^{-at_1})e^{-at}$, occurring alternately at intervals of t_1 .

Once a non-sinusoidal periodic wave has been decomposed into component waves, the over-all circuit response can be obtained by superimposing the individual circuit responses on the component waves. These responses are similar in their wave form but start at different instants. Two examples, one for a square-wave voltage applied to R and C in series and the other for the output current of a bi-phase

controlled rectifier supplying an inductive load, will be used to show the procedure used in both the analytical and graphical versions of this short-cut method of determining circuit response.

Circuit Response to Square Waves

Suppose it is required to find the transient response of a circuit to a symmetrical square-wave voltage having a magnitude A and a period $2t_1$. This involves finding the response during the existence of the n th square wave after the square-wave voltage is applied.

Analytical Solution

Taking the analytical solution first, assume that time is zero at the beginning of the $(n + 1)$ th square wave, n being an even number. The component waves are

Component Wave	Magnitude	Instant at Which Wave Starts
$n + 1$	$+2A$	0
n	$-2A$	$-t_1$
$n - 1$	$+2A$	$-2t_1$
$n - 2$	$-2A$	$-3t_1$
\dots	\dots	\dots
3	$+2A$	$-(n - 2)t_1$
2	$-2A$	$-(n - 1)t_1$
1	$+A$	$-nt_1$

Let $i_{n+1}, i_n, \dots, i_2, i_1$ be the current responses to the $(n + 1)$ th, n th, $\dots, 2$ nd and 1st component waves respectively. Now, since the response of the circuit is a function of time [written $f(t)$, with its significance depending on the particular combination of circuit elements in the circuit], the individual circuit responses to the component waves may be specified as follows in the general analytical solution where time is defined as $t_1 \geq t \geq 0$:

$$i_{n+1} = 2A f(t) \quad (1)$$

$$i_n = -2A f(t + t_1)$$

$$i_{n-1} = 2A f(t + 2t_1)$$

$$i_2 = -2A f[t + (n - 1)t_1]$$

$$i_1 = A f(t + nt_1)$$

The total current response is

$$i = i_1 + i_2 + i_3 + \dots + i_n + i_{n+1} \\ = 2A \sum_1^n (-1)^{s-1} f(t + st_1) - A f(t + nt_1) \quad (2)^*$$

$t_1 \geq t \geq 0$

where s is any integral number between 1 and n .

Equation (2) is a general solution of the circuit response to a square wave from its known response to a Heaviside unit function. The steady-state solution can be obtained by making n approach infinity.

* Equation (2) is also true when n is odd.

As an example of the analytical solution, suppose the circuit is made of a resistance R and a capacitance C in series. The circuit response to a Heaviside unit function $f(t)$ will be $(1/R)e^{-t/CR}$, and the total current response will be

$$i = \frac{2A}{R} e^{-t/CR} \left[\sum_1^n (-1)^{s-1} e^{-st/CR} \right] \\ - \frac{A}{R} e^{-(t+nt_1)/CR} \quad t_1 \geq t \geq 0 \quad (3)$$

The expression in brackets is a familiar geometric series. When its sum is substituted in Eq. (3), the total current response becomes

$$i = \frac{2A}{R} e^{-t/CR} \left[\frac{1 - e^{-(n+1)t_1/CR}}{1 + e^{-t_1/CR}} \right] \\ - \frac{A}{R} e^{-(t+nt_1)/CR} \quad t_1 \geq t \geq 0 \quad (4)$$

The steady-state solution can be obtained by letting n approach ∞ :

$$i = \frac{2A}{R} e^{-t/CR} \left[\frac{1}{1 + e^{-t_1/CR}} \right] \quad t_1 \geq t \geq 0 \quad (5)$$

The graphical solution for the current response during the first four square waves is summarized in Fig. 10. It is performed by plotting the circuit responses to component waves which have a magnitude of A for the first component and $-2A$ and $+2A$ and alternatively for the successive components, spaced at a time interval of t_1 . Superimposing all the responses gives the resultant current response, shown at the bottom in Fig. 10. The graphical method is

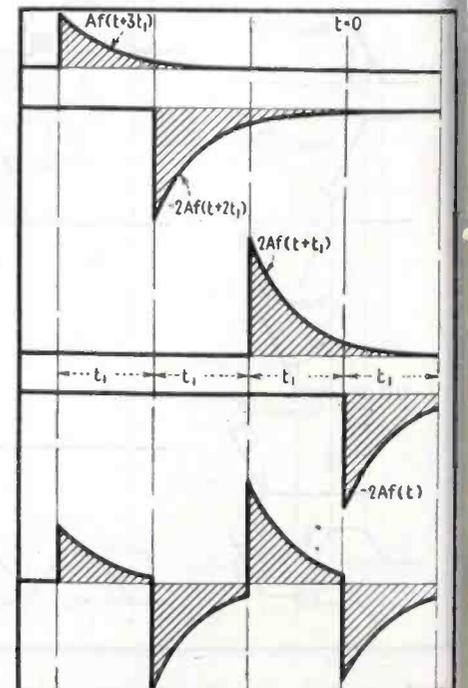


FIG. 10 — Current response where square-wave voltage is applied to R and C in series

venient in obtaining the transient response during the first few cycles, but as time goes on, the manipulation becomes more and more tedious and the result less and less accurate.

Current Response of Bi-Phase Controlled Rectifier

With an inductive load consisting of a resistance and an inductance in series supplied by a controlled rectifier of the gaseous discharge type, the current during successive conduction periods will be different after the closing of the switch if the conduction is continuous. It is required to find the transient current response at any instant during the existence of the *n*th rectified voltage wave after the closing of the switch

Again starting with the analytical solution, the peak value of the anode voltage is *A*. The phase retard of the controlled rectifier can be expressed as θ_f , electrical degrees. The time interval equivalent to 180 electrical degrees is t_1 , and is equal to $\omega = 1/2f$. The beginning of *n*th rectified wave is taken as the zero axis of time.

Component Wave	Magnitude	Time at which Wave Starts	
		In Elec. Deg.	In Sec.
<i>n</i> th	2 <i>A</i>	0	0
(<i>n</i> -1)th	2 <i>A</i>	π	$-t_1$
(<i>n</i> -2)th	2 <i>A</i>	2π	$-2t_1$
.....
2	2 <i>A</i>	$(n-2)\pi$	$-(n-2)t_1$
1	<i>A</i>	$(n-1)\pi$	$-(n-1)t_1$

The transient current response of an inductive load consisting of *R* and *L* in series to a unit sinusoidal wave closing at $\sin(\omega t + \theta_f)$ is¹⁰

$$i = \frac{1}{Z} \sin(\phi - \theta_f) \epsilon^{-\alpha t} + \frac{1}{Z} (\omega L - \phi + \theta_f) \tag{6}$$

which

$$Z = [(\omega L)^2 + R^2]^{0.5}$$

$$\theta = \tan^{-1}(\omega L/R)$$

$$\alpha = R/L$$

then the current responses to component waves are

$$i = \frac{2A}{Z} \sin(\phi - \theta_f) \epsilon^{-\alpha t} + \frac{2A}{Z} \sin[\omega t - \phi + \theta_f]$$

$$i = \frac{2A}{Z} \sin(\phi - \theta_f) \epsilon^{-\alpha(t+t_1)} + \frac{2A}{Z} \sin[\omega t - \phi + \theta_f + \pi]$$

$$i = \frac{2A}{Z} \sin(\phi - \theta_f) \epsilon^{-\alpha[t+(n-2)t_1]} + \frac{2A}{Z} \sin[\omega t - \phi + \theta_f + (n-2)\pi]$$

$$i = \frac{A}{Z} \sin(\phi - \theta_f) \epsilon^{-\alpha[t+(n-1)t_1]} +$$

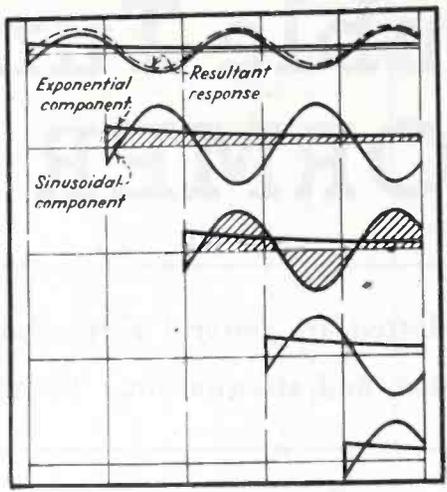


FIG. 11 (above)—Responses to component voltage waves of a controlled gaseous rectifier, for an inductive load

FIG. 12 (right)—Total response for arrangement of Fig. 11 is obtained by combining each type of component voltage separately, then combining the two resultant wave forms

$$\frac{A}{Z} \sin[\omega t - \phi + \theta_f + (n-1)\pi] \quad t_1 \geq t \geq 0 \tag{7}$$

The total current response is

$$i = i_1 + i_2 + \dots + i_{n-1} + i_n$$

$$= \frac{2A}{Z} \sin(\phi - \theta_f) \epsilon^{-\alpha t} \left[\frac{1 - \epsilon^{-n\alpha t_1}}{1 - \epsilon^{-\alpha t_1}} \right] - \frac{A}{Z} \sin(\phi - \theta_f) \epsilon^{-\alpha[t+(n-1)t_1]} + \frac{A}{Z} \sin(\omega t - \phi + \theta_f) \quad t_1 \geq t \geq 0 \tag{8}$$

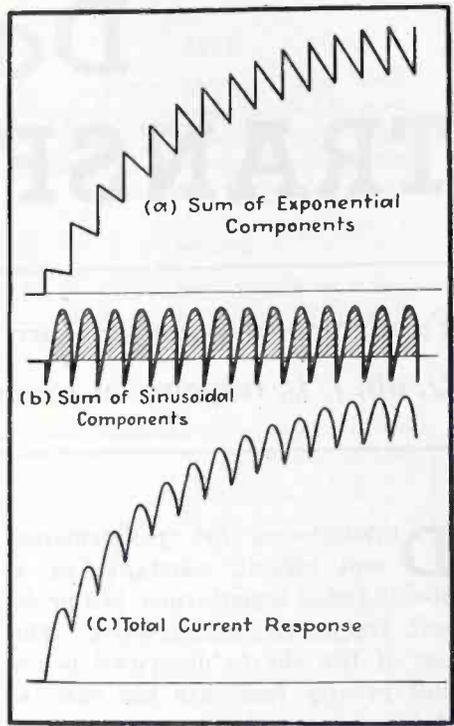
The steady-state solution, with $n \rightarrow \infty$, is

$$i = \frac{2A}{Z} \sin(\phi - \theta_f) \frac{\epsilon^{-\alpha t}}{1 - \epsilon^{-\alpha t_1}} + \frac{A}{Z} \sin(\omega t - \phi + \theta_f) \quad \pi \geq \omega t \geq 0 \tag{9}$$

Figure 11 shows the current responses to the component waves graphically. The exponential and sinusoidal components for each component wave are plotted separately. The resultant of exponential components, which is in the form of stepped exponential waves, is shown in Fig. 12(a). The sum of all sinusoidal components, which is a discontinuous periodic wave consisting of 180 electrical degrees of sine wave starting from $\sin(\phi - \theta_f)$, is shown in Fig. 12(b). The total response is the sum, shown in Fig. 12(c).

Conclusions

The principle of decomposing some types of non-sinusoidal waves into waves of the same wave form



but starting at different instants can be utilized as a short-cut method to obtain both the transient and the steady-state circuit responses to these waves.

The mathematical analysis involved in this method is comparatively simple and fundamental. It can be performed by those who do not have an adequate training in higher engineering mathematics, such as Laplacian transformation often used as a tool in solving problems of this nature.

The graphical analysis is very convenient for evaluating the transient response during the first few cycles, but may become more tedious and less accurate for evaluating the steady-state response, especially for circuits with large time constants.

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Double-Tuned TRANSFORMER DESIGN

Fundamental equations are plotted in general form showing the relations between k , Q , db , f/f_0 , response at resonance, and attenuation. Examples illustrate use of curves

DETERMINING the performance and circuit constants of a double-tuned transformer is a problem frequently encountered. The use of the charts described below will greatly facilitate the calculations.

The general expression for the attenuation of two identical coupled circuits is¹

$$db = 20 \log \frac{\sqrt{4 \left(Q \frac{\Delta f}{f_0} \right)^2 + \left[1 + (Qk)^2 - \left(Q \frac{\Delta f}{f_0} \right)^2 \right]^2}}{2Qk} \quad (1)$$

This relation is plotted in Fig. 1 so as to give the level variation of a

By **DAWKINS ESPY**

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family of Qk curves with respect to $Q(\Delta f/f_0)$.

The coupling between the two coils, k , and the Q of the coils is related to width of the pass-band by²

$$\frac{\Delta f}{\sqrt{2} f_0} = \sqrt{k^2 - 1/Q^2} \quad (2)$$

where $\Delta f/f_0$ is the fractional frequency deviation. The $\sqrt{2}$ converts from peak separation to bandwidth³. The level change in the pass-band may be obtained by setting $\Delta f/f_0 = 0$

in Eq. (1) and dividing the result by 2 in order to obtain the variation in gain from the average, as a function of coupling. This leads to

$$\Delta db = 10 \log \frac{(Qk)^2 + 1}{2Qk} \quad (3)$$

Equations (2) and (3) are plotted simultaneously in Fig. 2. This chart gives the solution of the problem involving the four variables k , Q , $\Delta f/f_0$, and Δdb , with any two of them known. Since k is usually an adjustable variable, there are three possible cases

<i>Known</i>	<i>Unknown</i>
(1) $\Delta f/f_0$ and Δdb	Q and k
(2) $\Delta f/f_0$ and Q	Δdb and k
(3) Δdb and Q	$\Delta f/f_0$ and k

The relative response at resonance, due to variations in Qk , is obtained from the reciprocal of the expression resulting from setting $\Delta f/f_0 = 0$ in Eq. (1). This gives

$$\text{Gain reduction factor} = \frac{2Qk}{(Qk)^2 + 1} \quad (4)$$

The solid curve in Fig. 3 is plotted from Eq. (4). The factor used to determine the average gain in the pass-band, as a function of Qk , is obtained by averaging the gain reduction factors at maximum pass-band gain and at resonance. This yields

$$\text{Gain reduction factor} = \frac{(Qk + 1)^2}{2[(Qk)^2 + 1]} \quad (5)$$

A plot of this expression for values of $Qk \geq 1$ is shown by the dashed line in Fig. 3.

Design Considerations

Design requirements of double-tuned r-f transformers ordinarily involve some particular attenuation at a given frequency-deviation from resonance. Knowing the required response in db, $\Delta f/f_0$, and the

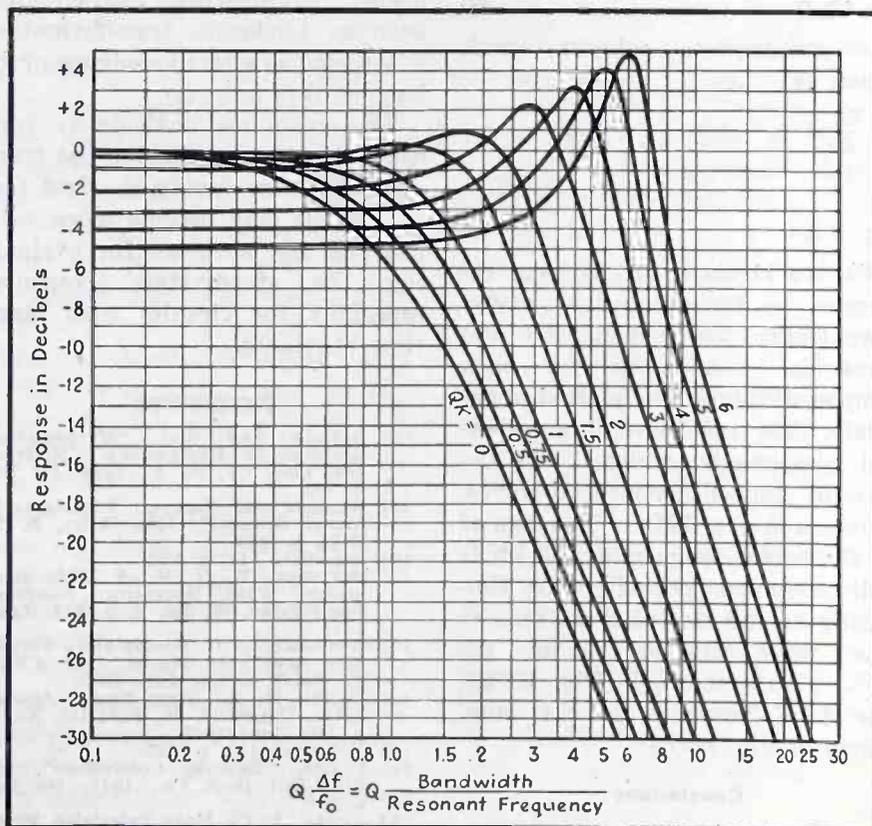


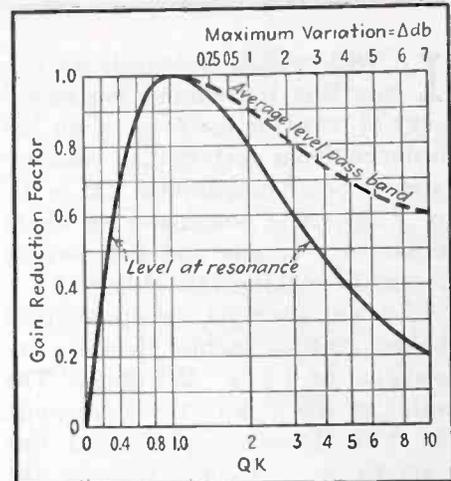
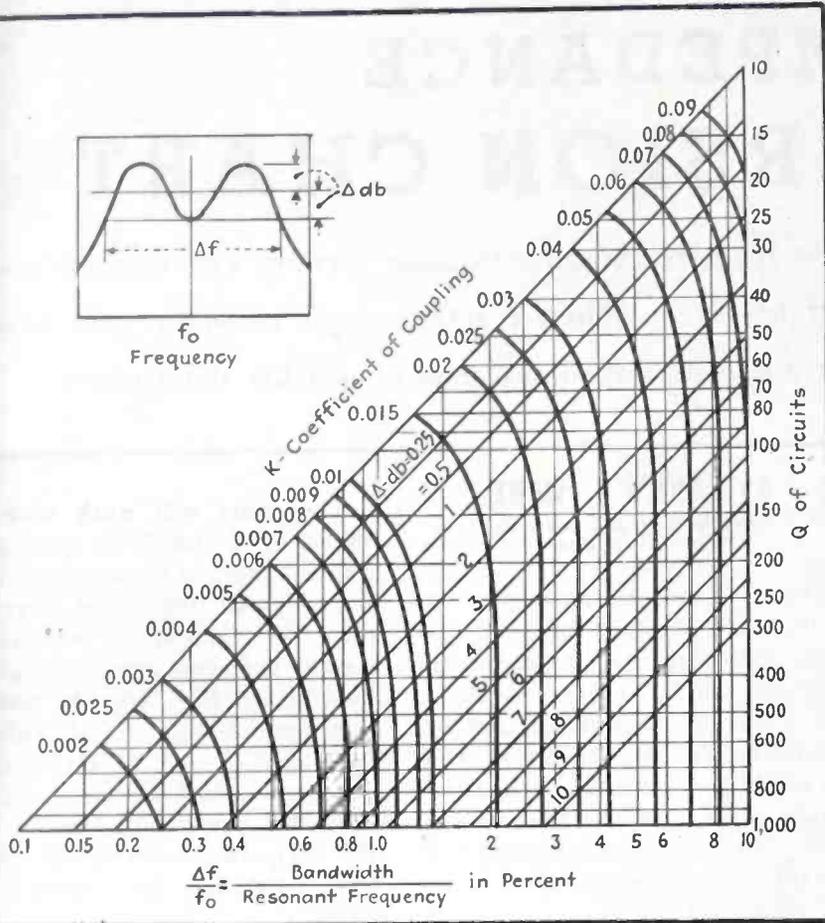
FIG. 1—Universal selectivity curves, showing deviation from average pass-band response vs deviation from resonance

LEFT

FIG. 2—Three-parameter chart giving the relation between frequency deviation, coupling coefficient, and circuit Q for values of maximum response variation within the band

BELOW

FIG. 3—Output level plotted as a function of the product of coupling coefficient and circuit Q



available Q , the required Qk is determined from Fig. 1, and thus the value of k is found. If attenuation at a specific point has been the design criterion, the resulting Δdb can be determined from Fig. 2. Frequently a transformer must be designed with a certain allowable response deviation from the average pass-band response. Usually the deviation, given in the charts as Δdb , the width of the band, given as Δf , and the resonant frequency, f_0 , are known. By using Fig. 2, it is possible to calculate the corresponding Q and k . The resulting attenuation at various frequencies can be determined by the use of Fig. 1.

Design Procedure

1. Determine Q , k , $\Delta f/f_0$ and Δdb from Fig. 2.
2. Calculate maximum gain from $(g_m X_L Q/2)$ where g_m is the transconductance of the tube driving the transformer, and X_L is the reactance of either coil at f_0 .
3. From Qk or Δdb , find the gain-reduction factor from Fig. 3 and multiply it by the gain obtained in step 2 to obtain actual gain.
4. Determine the gain at any por-

tion of the response curve from Fig. 1.

Examples

1. An i-f transformer operating at 456 kc with a tube having a g_m of 3000 μ mhos is required to have a pass-band of 16 kc. The response must not vary more than one db from the average. The inductance of each transformer winding is 250 μ h. Find Q , k , the average gain, and the attenuation at 20 kc from resonance.

Calculating $\Delta f/f_0 = 16/456 = 3.51$ percent

From Fig. 2: $Q = 70$; $k = 0.028$
 Max. gain = $g_m X_L Q/2 = 3000 \times 10^{-9} \times 2\pi \times 456 \times 10^3 \times 250 \times 10^{-6} \times 70/2 = 75.2$

Average gain in pass-band $75.2 \times 0.9 = 67.7$, where the 0.9 is read from Fig. 3.

For 20 kc deviation, $\Delta f = 40$ kc and

$(Q\Delta f/f_0) = (70 \times 40/456) = 6.14$
 $Qk = 70 \times 0.028 = 1.96$

From Fig. 1 the attenuation = 18 db.

2. An i-f transformer is required to work at 3 Mc with a tube which has a g_m equal to 5000 μ mhos, and using a 30- μ h coil with a Q of 200.

Find k and gain at resonance to give a compromise between gain and selectivity. Determine the gain at bandwidths of 10, 25, 50 and 75 kc.

A value of $Qk = 0.5$ is a good compromise between gain and selectivity, reducing the gain to 0.8 of the value obtained at critical coupling (Fig. 3), while improving the selectivity (Fig. 1).

For $Qk = 0.5$, $k = 0.5/200 = 0.0025$

Max. gain = $g_m X_L Q/2 = 283$

Gain at resonance = $283 \times 0.8 = 226 \approx 47.1$ db

$Q/f = 200/3000 = 0.0667$

From Fig. 1

Δf in kc.....	10	25	50	75
$Q(\Delta f/f_0)$	0.667	1.667	3.333	5.000
Attenuation in db from Fig. 1.....	2.2	9.3	19.5	26.0
Gain in db: 47.1 minus Attenuation	44.9	37.8	27.6	21.1

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IMPEDANCE CONVERSION CHART

Conversion of complex quantities from rectangular to polar form or vice versa is readily accomplished, using only a straight-edge. When reactance and resistance are known, the magnitude and phase angle of impedance may be quickly determined

IN THE COURSE of impedance calculations, it often becomes necessary to transfer the form of an impedance from rectangular coordinates to polar coordinates ($R + jX = Z\angle\phi$). The accompanying chart provides a simple and time-saving means of making this change.

As an example, suppose that bridge measurements yield an impedance of $1.5 + j2.0$ ohms. The value of R/X is in this case equal to 0.75. Drawing a vertical line (shown as a dashed line on the chart) through 0.75 on the horizontal scale, it will be seen that this line intersects the phase-angle curve on the chart at a value of 36.9 degrees. This angle, θ , is the complement of the true phase angle, 53.1

By **PERRY H. WARE**

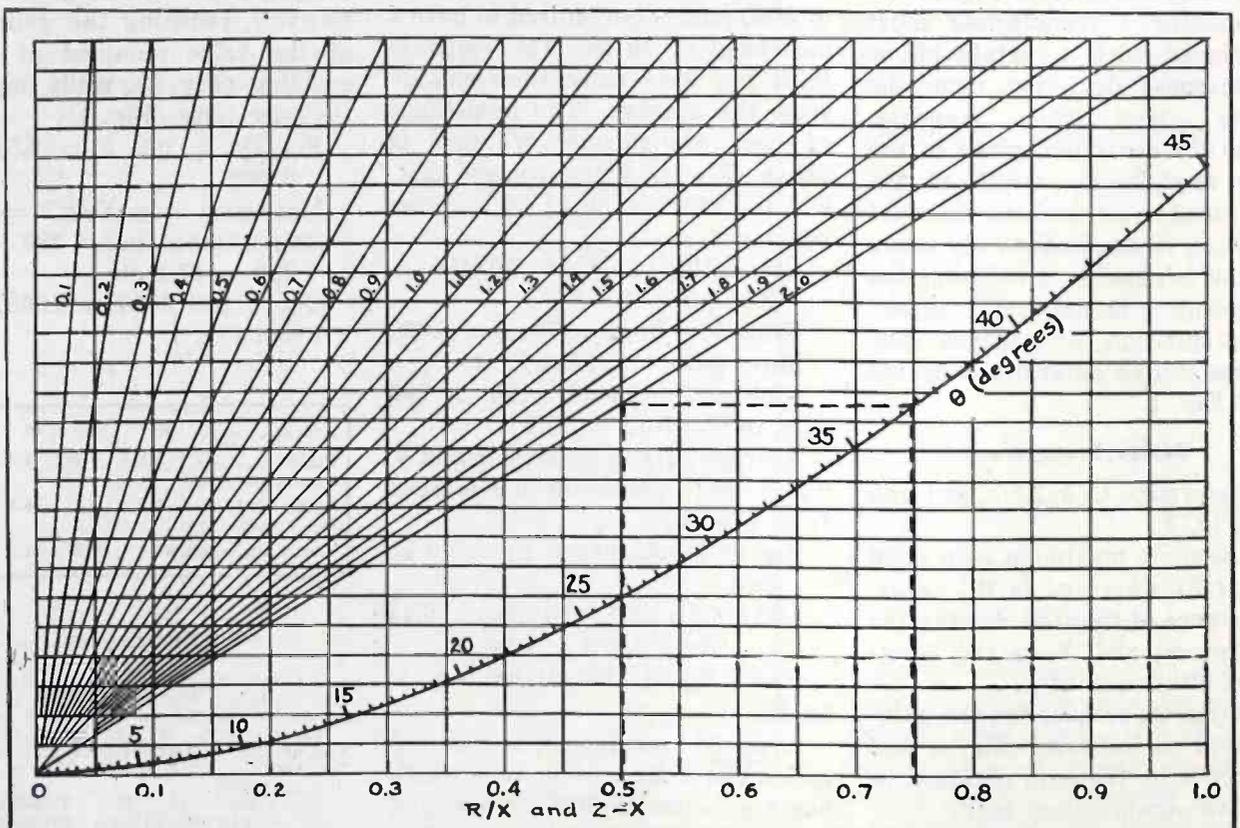
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degrees. Drawing a horizontal line to the left from 36.9 on the phase-angle curve until it intersects the diagonal line 2.0 corresponding to the value of X , then dropping a perpendicular to the horizontal scale, we obtain a correction $Z-X$ of 0.5, which when added to the value of $X = 2.0$, yields the impedance, Z , equal to 2.5; therefore $1.5 + j2.0 = 2.5\angle 53.1^\circ$.

If R is larger than X , the ratio X/R is used as the original argument, and θ is the phase angle directly as read. The diagonal line corresponding to R rather than X is used, and correction is added to R .

The chart will work with any values of X and R , by moving the decimal point in the scales of X (or the diagonal lines) and correcting term $Z-X$ (on the scale of abscissas) the same number of places leaving the R/X scale as marked. For example, $20 + j15$ yields a value of $X/R = 0.75$, giving a phase angle equal to 36.9 degrees. Considering the line $R = 2.0$ as $R = 20$, the correction term is 5.0, rather than 0.50, and the impedance is $25\angle 36.9^\circ$.

The inverse operation ($Z\angle\phi = R + jX$) may also be carried out by means of estimated values, and practice will enable the user of the chart to carry out the computation quite rapidly.





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INDUSTRIAL CONTROL

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Machining Control Cuts Finishing Time

A REDUCTION in finishing time from 13½ hours to 5 minutes in the machining of aluminum spar beams for plane wings has been accomplished at one Cleveland aircraft plant, with the help of General Electric Thy-mo-trol installed on a large automatic contour milling machine designed and built by the Onsrud Machine Works, Inc. of Chicago.

The spar beams are long, one-piece structural channels which run lengthwise through the wing, from fuselage to wing tip. Wing ribs and cap strips are fastened on the beams to make up the rigid framework of the wing. The spar must be machined accurately to permit perfect joining of ribs and cap strips, and it must also be contoured exactly to conform with the irregular shape of the wing itself.

The carriage of the milling machine houses four cutter motor as-

semblies, providing two horizontal and two vertical cutters which turn at 3,600 and 10,800 rpm, ideal speeds for the aluminum alloys involved. Each cutter is controlled by a follower which travels over a template or former bar as the carriage moves from one end of the table to the other. The bed and table are long enough to permit machining the long spar in a single setup. With the four cutters, every type cut required by spar beam design may be made, such as face, slot, and side milling, twist cutting, beveling, and making cutouts for weight reduction.

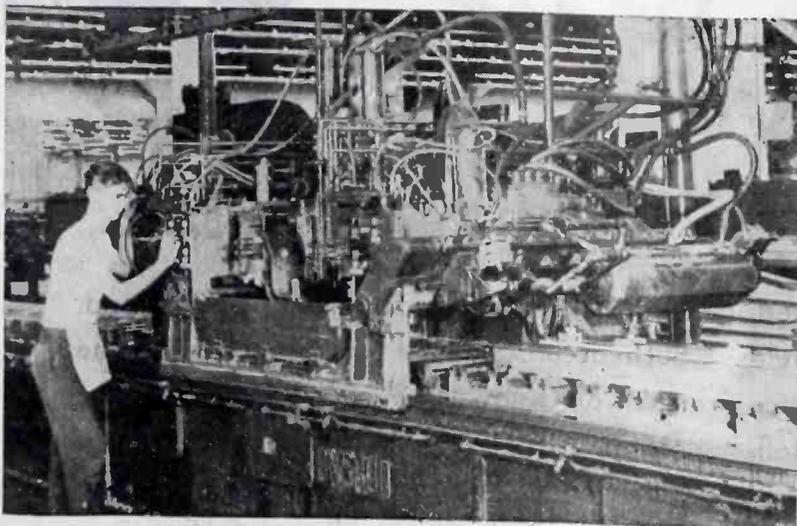
Carriage Control

Need for a flexible carriage speed control was met by the Thy-mo-trol drive, which assures that the cutters are fed to the work at all times in proper relation to the changing contours of a spar beam. For ex-

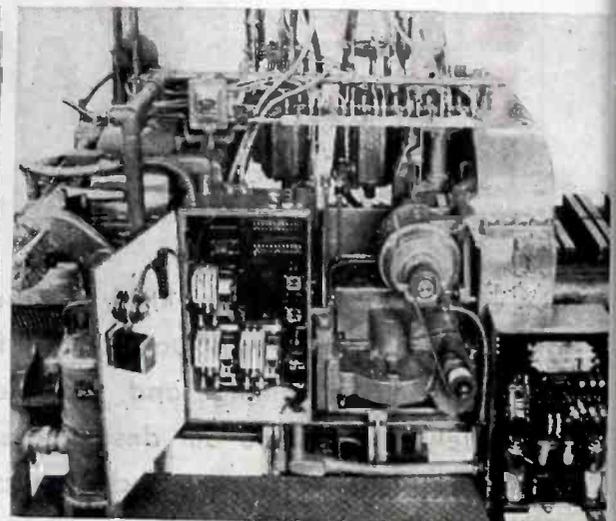
ample, in one pass over the table the depth of cut may increase and decrease several times while the number of cutters entering the work may change from one to four. Such varying conditions require a change of feed to avoid overloading of the cutter motors. Moreover a fast "skip" speed was essential to save time when no cutting at all is necessary.

With the electronic system, a-c power is converted to d-c to obtain a stepless speed range with a rheostat-controlled d-c carriage-drive motor. The control unit makes possible a carriage feed at any speed from 4 in. to 18 ft 6 in. per minute. This infinitely variable speed within the established limits has resulted in the topspeed machining of the complex spar beam at all times.

An automatic cam bar feed designed by Onsrud engineers makes it unnecessary for the operator to judge the maximum speeds at which the carriage can be fed during the many different conditions encountered in a pass. During carriage feed, a rheostat-connected follower travels over the cam bar, which is contoured accurately in proper relation to the work. Up-and-down travel of the follower as governed by the cam varies the control of the rheostat, and at every point of the pass the mechanically pre-determined carriage speed is at the exact maximum that work will permit.



Automatic contour milling machine in operation. Equipped with G-E Thy-mo-trol, it does in 5 minutes a finishing operation in the machining of aluminum spar beams that formerly took 13½ hours



Close-up of G-E Thy-mo-trol panel and a-c magnetic controller (at left, door open) on the milling machine. The control panel at right without cover is for the 2-hp motor (center) which drives the carriage feed

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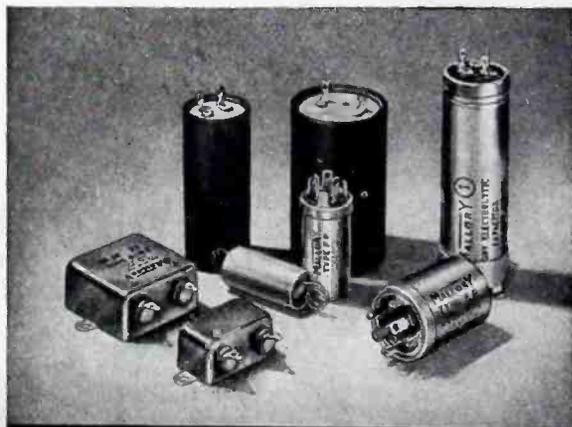
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Developed especially for the Aberdeen Grounds by RCA Laboratories at Princeton, N. J., the electronic time-interval counter is designed to measure, with great accuracy, a time interval in the order of 0.01. Extreme accuracy is obtained through the ability of the device to give this measurement to within 0.00001 second. The research on this device was brought to fruition, and a very practical device made available to the military services through the work of Igor E. Grosdoff, RCA research engineer.

Principle of Operation

Each range is equipped with two electrical coils, arranged so that a projectile will pass through them in

succession. By magnetizing the projectile, a small electrical signal is generated by each coil as the bullet passes through. If the coils are 30 feet apart, and the time between the two signals is 0.01 second, the bullet is traveling 3,000 feet a second. The measurements can be made at the rate of hundreds of observations a day.

The counter consists of three essential parts: an oscillator, a gate, and the counter proper. The frequency of the oscillator is controlled, as in a radio transmitter, by a quartz crystal ground to operate at precisely 100 kc. The gate is a vacuum-tube circuit which passes the pulses into the counter, which counts them and finally, when the gate is closed, shows by indicator lamps the number of pulses that have passed through. Thus, it shows the number of hundred-thousandths of a second from the time the gate opened until it closed.

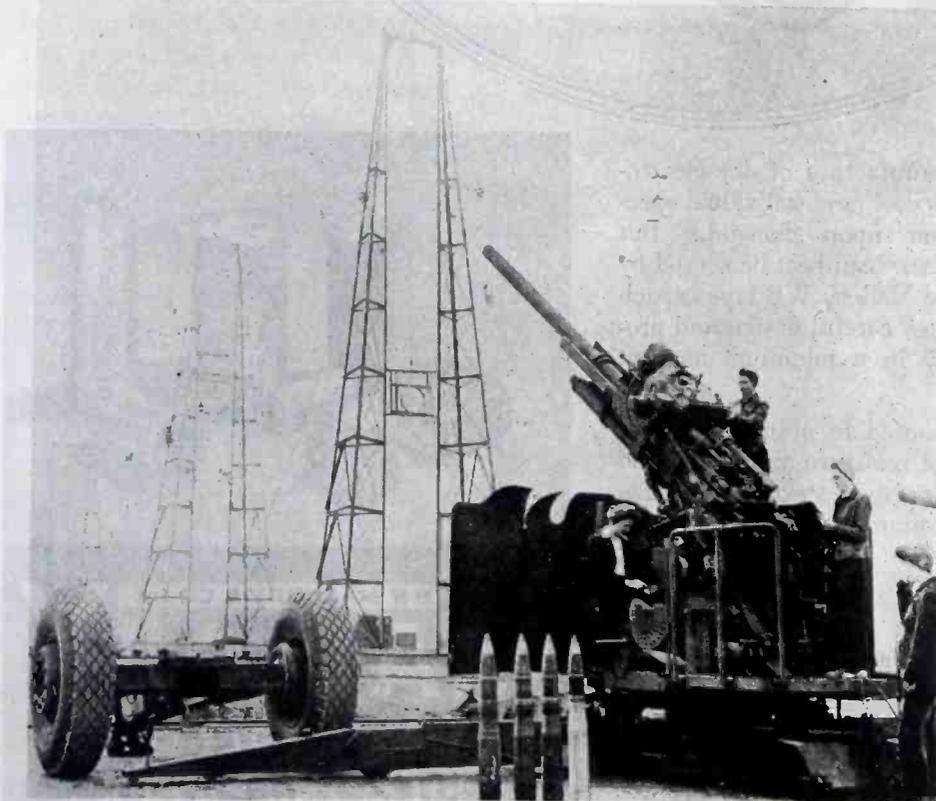
In operation on the firing ranges, the counter's gate is opened by the electrical signal from the first coil as the bullet passes through it, and is closed again by the impulse from

the second coil. The operator records the time of flight between coils and computes the velocity. This is noted down along with the record of the particular gun and projectile being tested for subsequent analysis by ballistic experts. The operator then touches the reset button and is ready to repeat.

Electronic Sorting Table for Small Parts

MUCH GREATER SPEED in the sorting and inspection of tiny contact assemblies produced at General Electric's Schenectady Works has been made possible through the development of an electronic sorting table which routes the assemblies into three different channels depending on whether they are too high, too low, or within the tolerances.

Previously, the contact assemblies, each almost small enough to require handling with tweezers



Shells from this 90-mm gun are magnetized, then shot through coils suspended from the towers. In passing through each coil, a voltage is generated and recorded on a chronograph. Electronic equipment permits determining the time interval to within a hundred-thousandth of a second

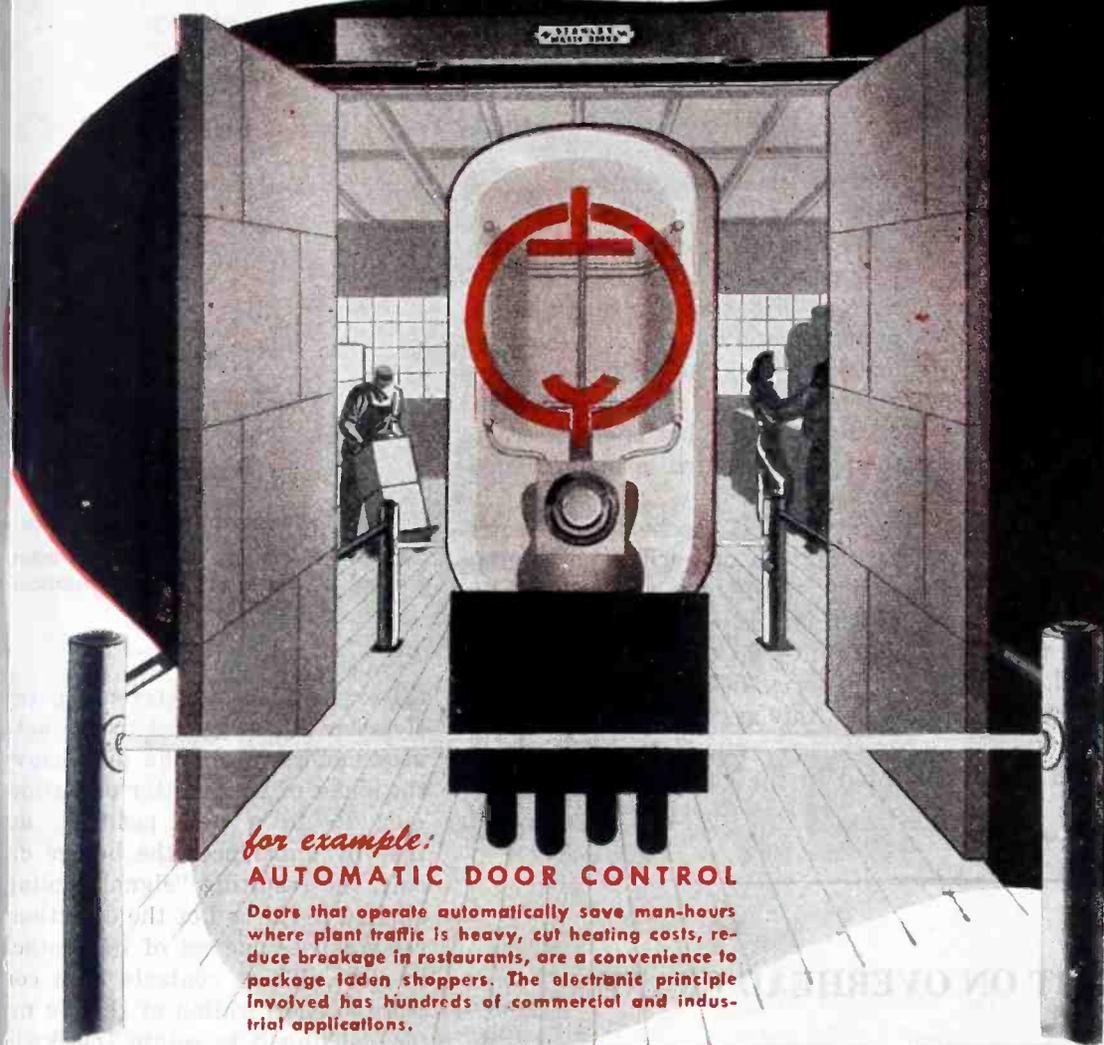


Small assemblies being fed onto a slide for electronic sorting. The chutes for oversize and correct-size assemblies are located at lower left. Units that are too small travel the full length of the slide

were sorted and inspected by hand. Each assembly was checked with a needle micrometer to determine whether it was oversize, undersize, or within the tolerances, and then sorted accordingly.

The specially designed sorting table incorporates an electronic relay and a factory-constructed "contact head." Each assembly is fed

wherever a tube is used...



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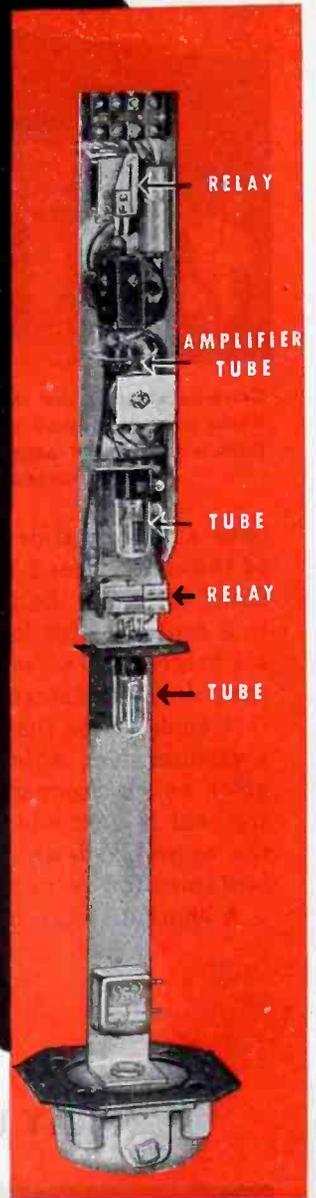


PHOTO-ELECTRIC DOOR CONTROL
 Above unit manufactured by General Electric Co., is a part of STANLEY "MAGIC DOOR" CONTROLS.

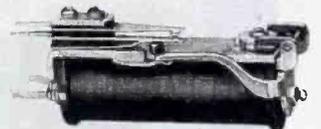
THERE'S A JOB FOR

Relays BY GUARDIAN

★ The "Magic Door" made by The Stanley Works of New Britain, Conn., uses a General Electric control unit which operates automatically at the approach of a pedestrian or vehicle. In this unit a beam of light focused on the cathode of a phototube causes a tiny current to flow. Enlarged through an amplifier tube this current operates a sensitive telephone type of relay such as the Guardian Series 405. Another phototube with an auxiliary relay, Guardian Series R-100, is employed to hold the doors open for anyone standing within the doorway.

The telephone type of relay is extremely sensitive and able to operate on the small current supplied through the electronic circuit. The auxiliary relay, Series R-100, is required to handle a greater current. It is a small, efficient relay having a contact capacity up to 1 KW at frequencies up to and including 28 megacycles. Contact combinations range up to double pole, double throw. Standard coils operate on 110 volts, 60 cycles, and draw approximately 7 V. A. Coils for other voltages are available. For further information write for Bulletin R-6.

Consult Guardian whenever a tube is used—however—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

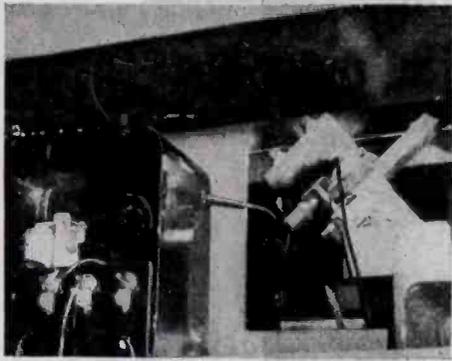


Series 405 Telephone Type Relay



Series R-100 H. F. Relay

GUARDIAN  **ELECTRIC**
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 A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY



Close-up view of the work table for electronic sorting of small assemblies. At the right is the contact head and at the left is the electronic relay

onto a 45-deg slide which is part of the contact head. About halfway down the slide, the assembly comes to a contact point located at a pre-set height. If the assembly touches the point, it is oversize, and the contact made closes the grid circuit of a vacuum tube, which in turn energizes an electromagnetic relay. A solenoid is next energized, sending the assembly down a chute into a container for oversize parts.

A short distance beyond the first

point, a second contact point is set at standard height less tolerance. Since oversize assemblies have already been eliminated at the first contact point, parts touching the

second point are within acceptable limits and are "shot" down another chute. Undersize assemblies do not touch either point and slide undisturbed to a third tray.

Positioning Controls for Planes and Ships

FOR COMPLETELY ELECTRICAL remote positioning of rudders or other controls on airplanes or ships, it is possible to use a simple direct-current bridge circuit in which two potentiometers are connected in parallel across the d-c power source and the coil of a sensitive polarized or directional relay is connected to the movable contact arms of the potentiometers.

Figure 1 is a schematic electrical diagram of such a positioning control circuit. As shown here, the directional relay controls a reversible split-field direct-current motor with series-field windings F_1 and F_2 . In this system, the transmitter, or control potentiometer P_T , is located in the cockpit, while the re-

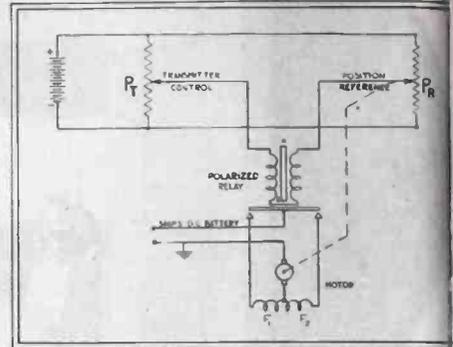


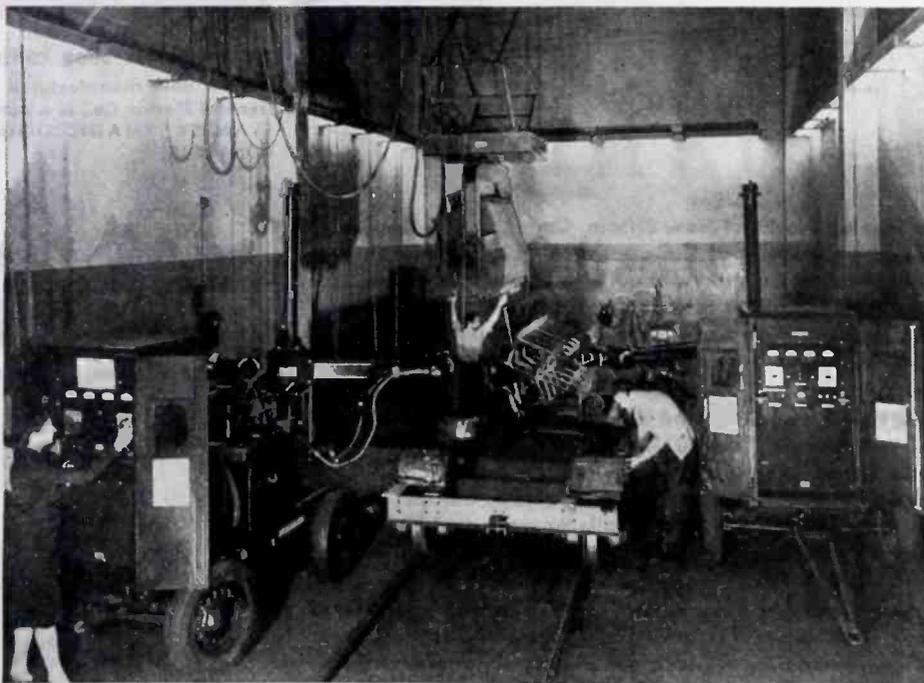
Fig. 1—Positioning control circuit using a balanced d-c bridge and polarized relay

ceiver, or position reference potentiometer P_R , is geared to the actuator motor. When the pilot moves the slider of transmitter potentiometer P_T to a new position, and thereby unbalances the bridge circuit, the resulting "signal" voltage applied to the coil of the directional relay causes one set of its contacts to close. These contacts then control the energization of the d-c motor, causing it to rotate (clockwise or counterclockwise) as required to move the actuator and the controlled aircraft members to the desired new position, corresponding to the pilot's setting of the transmitter control P_T .

The broken line connecting the motor and position reference potentiometer P_R represents the gearing which causes the motion of the slider of this potentiometer to be proportional to that of the controlled aircraft member and, therefore, when the latter reaches the desired position, the slider of potentiometer P_R matches the pilot's of P_T . The bridge is again balanced so that no further control signal voltage is applied to the coil of the directional relay, thus allowing its contacts to reopen. The motor is thereupon de-energized and the actuator remains in its new position.

Unless the relay is made exceptionally sensitive, the system shown is subject to positioning errors of

X-RAY UNIT ON OVERHEAD CRANE



Crankcases and other component parts for Navy ships are x-rayed for possible faults at Warren City Mfg. Co., Warren, Ohio. One of four of its kind in the country, the overhead x-ray equipment in the background can photograph steel plate up to 4 inches thick. Other portable industrial x-ray units appear in the foreground and extreme background

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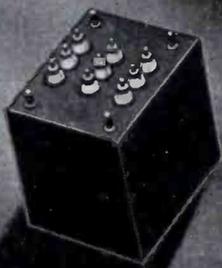




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the order of ± 2 percent to \pm percent of the total travel of the driven device. It is difficult to design such a system to provide for antihunt or stabilizing means in the electric motor control. Thus, due to the inertia of the motor, the speed of operation of the controlled member has to be limited and the width of the null, or backlash, zone must be considerably wider than is necessary in a system that may incorporate a proper degree of "anticipation."

Electronic Positioning Control

To avoid using an extremely sensitive and delicate relay on an aircraft to obtain higher positioning accuracy and also to provide absolute stability and antihunt features, an electronic control circuit has been developed in which the sensitive relay is replaced by a vacuum-tube and differential-relay combination. Such a system was described by William P. Lear of Lea Avia, Inc., in a paper delivered at a joint meeting of the Franklin Institute and the Philadelphia section of AIEE.

Figure 2 shows a schematic diagram of a positioning control circuit using the electronic tube—relay system with a balanced alternating-current bridge connected to the secondary S_1 of power transformer T_1 . In this circuit, the slid-

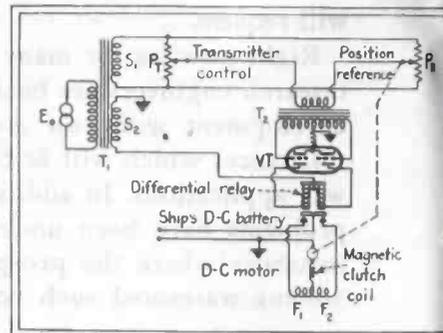
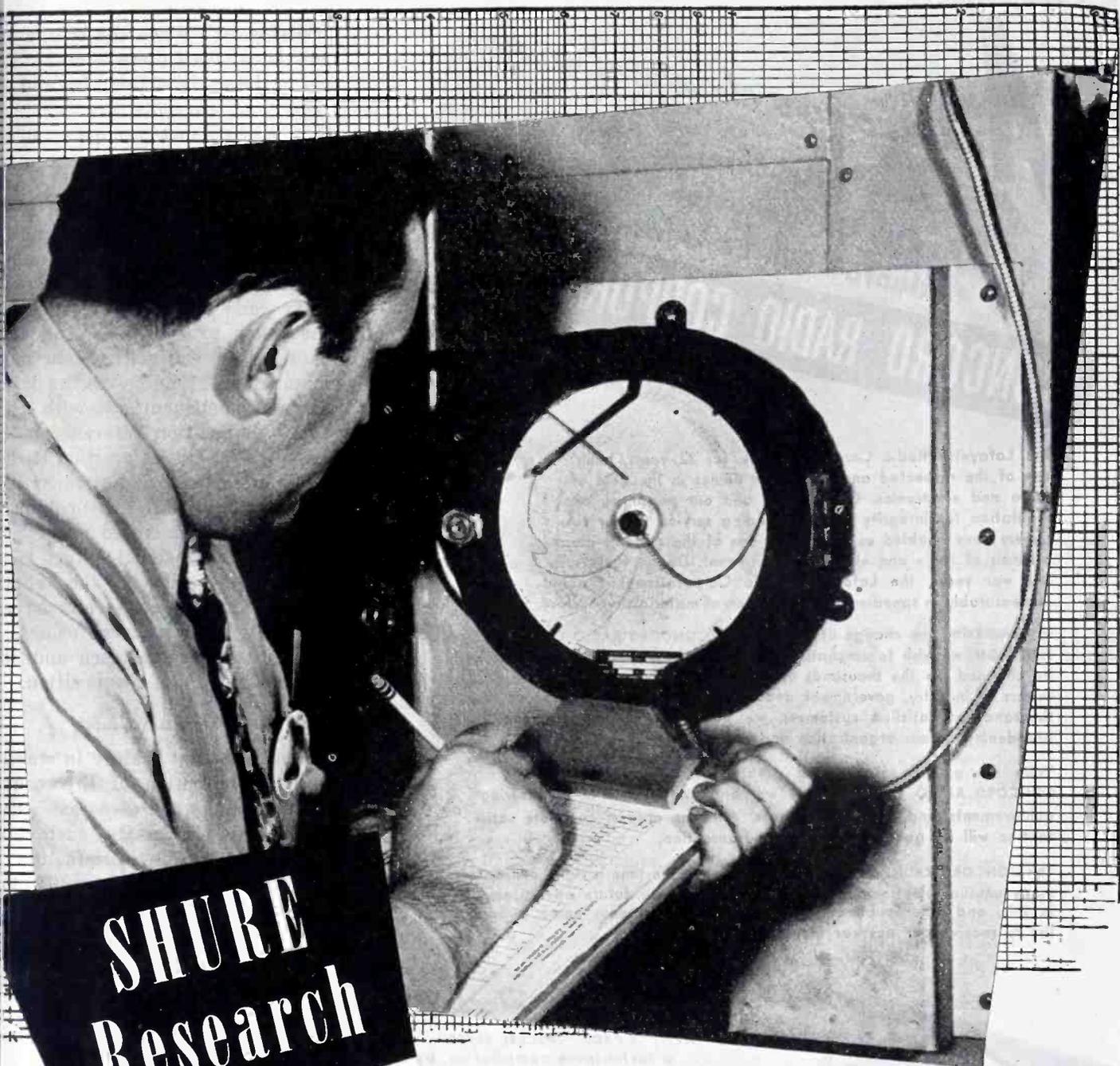


Fig. 2—Circuit of vacuum-tube system using an a-c bridge and relay for positioning control

ers of potentiometers P_T and P_R are connected to the primary of the grid transformer T_2 , which "steps up" the weak signal voltage before it is applied to the grids of the vacuum tube VT . The differential relay coils, which are connected respectively in series with the plates of the tube, receive their power from the secondary S_2 of the power



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transformer. When the bridge circuit is balanced there is no a-c signal to the grids of the tube, and the relay coil currents are balanced. The relay contacts are open and the motor is de-energized.

When the pilot moves the slide of transmitter potentiometer P_r to a new position, the tube amplifies and rectifies the resulting unbalanced signal voltage, causing one relay coil current to increase and the other to decrease. The relay operates to energize the actuator motor, which then moves the drive aircraft component, and with it the slider of position reference potentiometer P_r to the position corresponding to that of the transmitter potentiometer P_r . The bridge circuit is again balanced so that if further control signal voltage is applied to the grids of the vacuum tube VT and the relay coil current return to their balanced values, allowing the relay to open and stop the actuator in its new position.

Magnetic Clutch

An important feature in stabilizing the operation of this control system is the use of a fast-acting low-inertia clutch. One such clutch that has proven satisfactory in actual service is the Lear "Fastop" magnetic clutch which is electrically connected with the motor as shown in Fig. 2. As previously ex-

TWIST-TEST FOR C-R TUBES

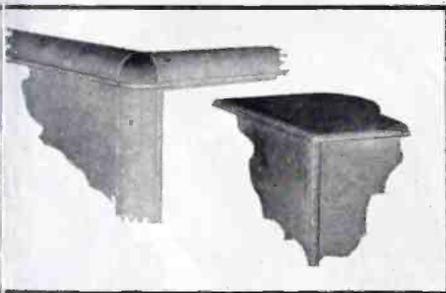


After soaking in warm water for 18 hours, cathode-ray tube bases are inserted in the holder shown above and the tube twisted against the torque of the weight on the arm. Virginia Connick tests the cement on the tube base in this manner at the Dobbs Ferry plant of North American Phillips

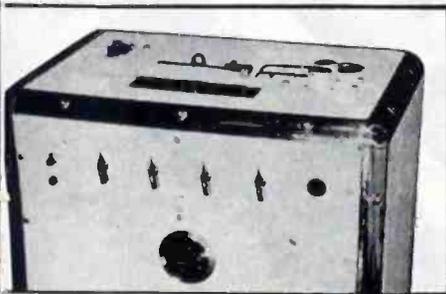
It's **1** STRONG... **2** NEAT...
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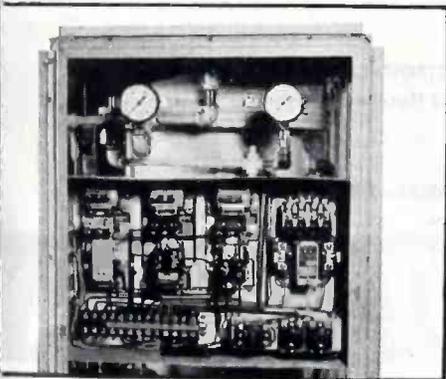
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U. S. Patents 2017629, 2263510, 2263511 — U. S. and Foreign Patents and Patents Pending

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It is commonly admitted in designing electrical equipment, that insulation presents the most difficult problem of all the construction elements.

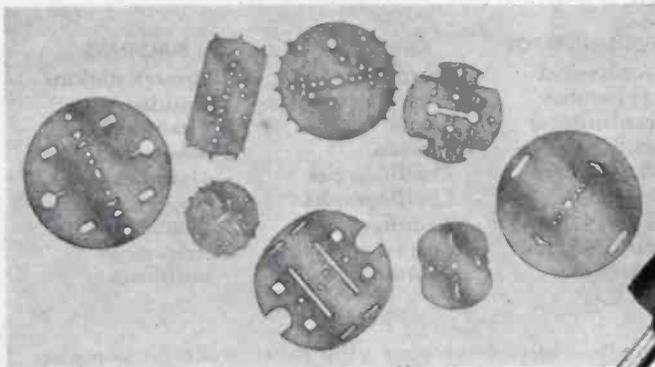
The facilities of the Mica Insulator Company as a single source for a great variety of insulating materials are available in the design and selection of insulation which will provide the necessary factor of safety under the higher operating temperatures, greater speeds and higher frequencies of today's electrical equipment.

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A few representative mica stampings for electronic tubes.



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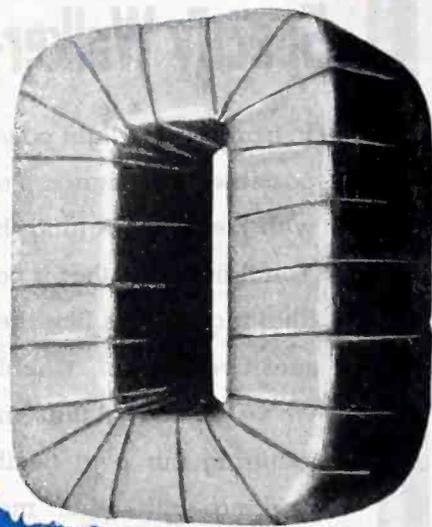
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Particular interest is this new EMPIRE "3 mil bias tape" which combines extreme thinness with excellent dielectric strength and elongation properties. It is especially adapted for use on irregularly shaped conductors; or for solenoid and instrument coils.

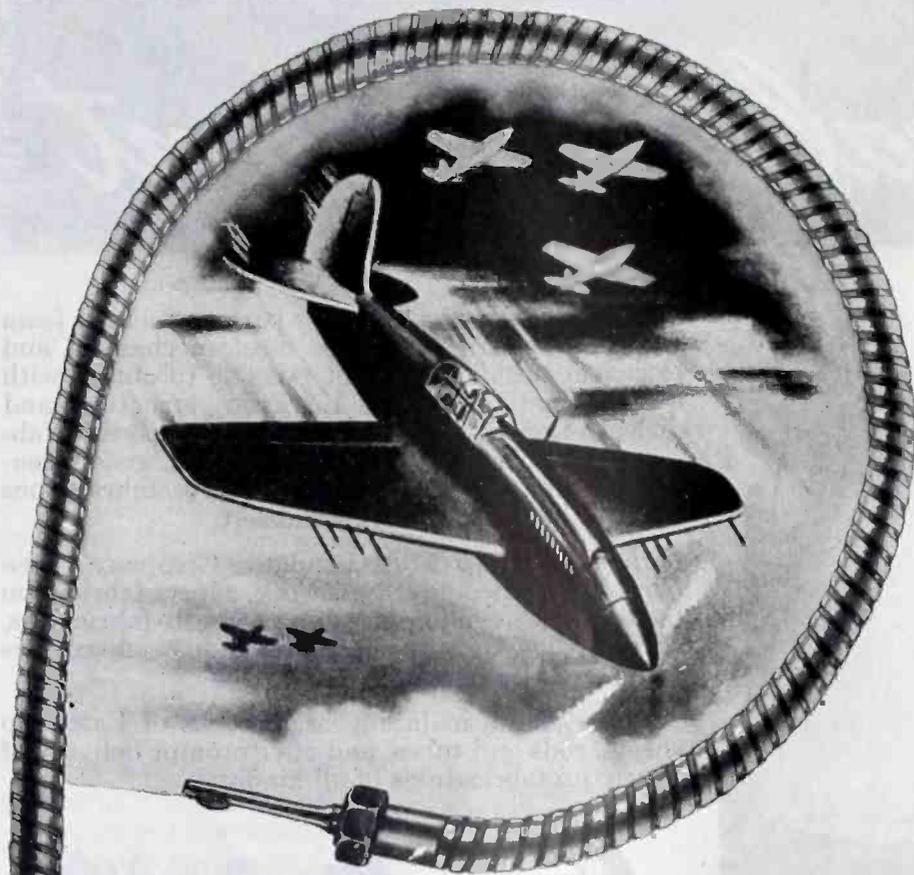
The EMPIRE line also includes a complete line of finished cloths and tapes and Varnished Fiberglass (Class B insulation).

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plained, this clutch disconnects the motor from the gearing actuator immediately upon de-energization of the motor and also permits the clutch member to brake the gearing, whereby the actuator and airplane member are almost instantly stopped. Other features will increase the stability or anti-hunt characteristics of the control system and can be incorporated in an arrangement similar to that shown in Fig. 2. It has been found that potentiometer-vacuum-tube-relay control system, as exemplified by Fig. 2, can position remotely to accuracies well within one percent of the total travel of the driven device. Such accuracies are ample for the positioning of most accessories and components on an aircraft, such as wing flaps, landing gear, shutter doors, cowl flaps, etc.

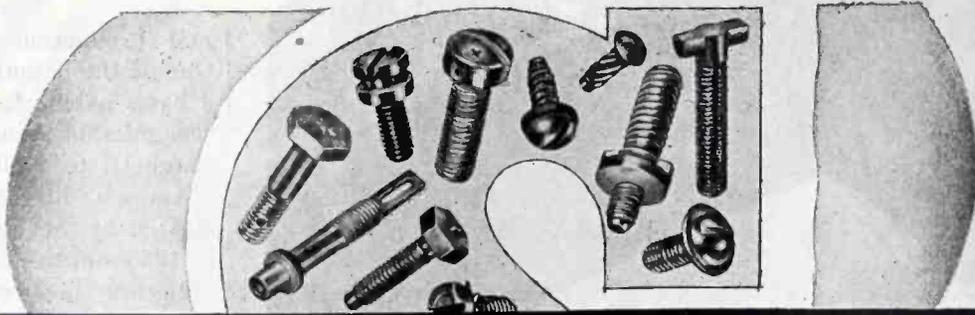
• • •

H-F Heating Patents

LICENSES COVERING the application of high-frequency heating in the production, processing and manufacture of rubber, plastics, wood and other products, are now available in this country under the patents of H. A. Leduc and R. A. DuFour. The main advantage of the processes and apparatus covered by the patents is that non-metallic dielectric materials can be rapidly and uniformly heated throughout their mass, and that temperature and temperature rise can be accurately controlled.

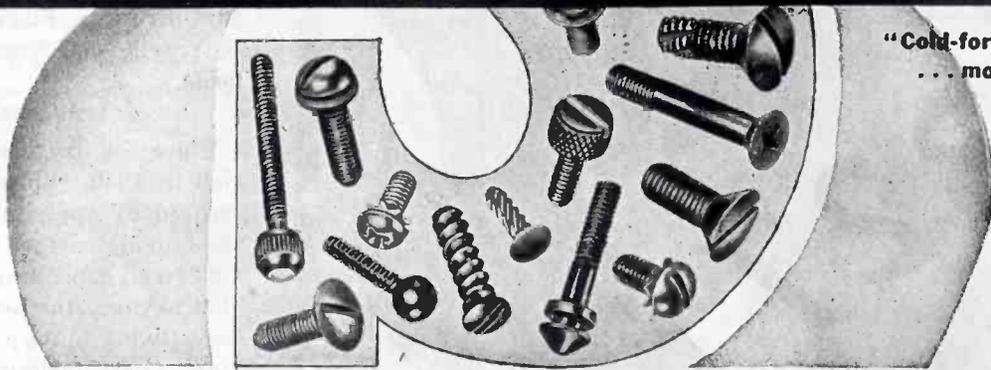
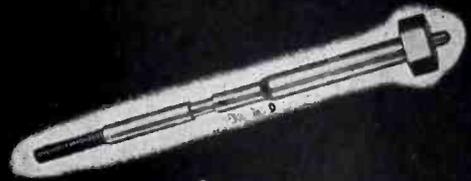
Originally developed by the inventors with a view to overcoming the difficulties inherent in the vulcanizing of massive rubber objects, the high-frequency heating process has become the means for making possible heat transfer in many poorly conducting or non-conducting materials.

According to the claims, the practical applications of the process in the rubber field include thermal plasticizing of bales of raw rubber; reclaiming by heat; vulcanizing of sponge, thick masses, roll coverings, rubber-coated metals, rubberized or plasticized parts, proofed goods and molded articles; concentration, sterilization and vulcanizing of stabilized latex; coagulation of heat-sensitized or electrically unstable latex; manufacture of insulated cables and wires.



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and production of latex sponge. One of the patents is claimed to be a basic patent for coagulating any "coagulatable fluid material", from spaghetti to wallboard.

Leduc's invention was demonstrated at the Exposition of Paris in 1935 and the French Rubber Association honored him with its medal. In a report to the French Senate, it was stated that the Dufour-Leduc inventions alone justified the more than 20 years of operation of the immense Government Research Center. In this country the B. F. Goodrich Co., Akron, Ohio will issue licenses covering rubber applications. W. H. Giodvad Grell, 33 University Place, New York 3, N. Y. will issue licenses in all other fields.

Advantage

Since the discovery of vulcanization in 1839, rubber has been vulcanized by applying steam heat to the outside surface of a rubber article and depending upon conduction to carry the heat into the rubber. Owing to its poor heat-conducting characteristics, the rubber was not heated uniformly and, in many cases, inferior articles were produced. In the electronic vulcanizing method, heat is generated inside the body of rubber so that large masses of rubber may be vulcanized quickly and uniformly.

Already finding extensive commercial application in the rubber and other industries, the electronic process promises to be used not only for vulcanizing rubber articles but also for the vulcanization of thermosetting materials. In many cases, the duration of the "cure" may be shortened enough to permit continuous conveyor vulcanization, where such practice would not be feasible otherwise.

• • •

Electronic Induction Heating on Production Line

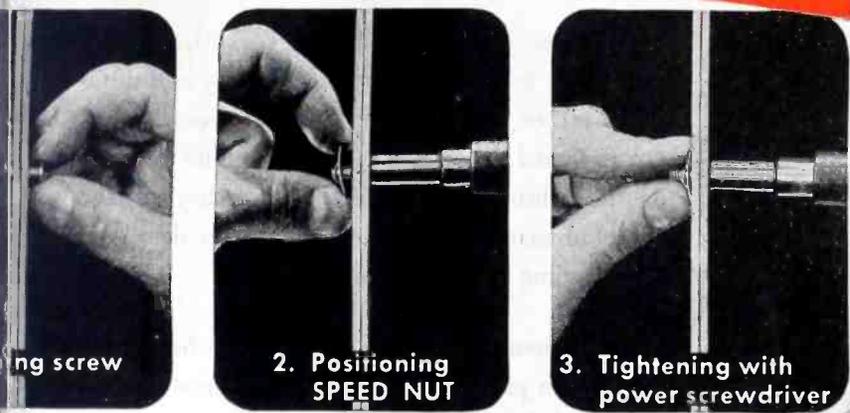
HIGH SPEED ELECTRONIC heating on a production line has been established for case-hardening finished bearing pins to a depth of 0.025 in. The pins were fed automatically through a glass tube and quenched with water as they left the heating coil at a rate of 75 pins per minute.

The r-f generator operated at a frequency of 5 megacycles and

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The SPEED NUT method requires only 3 hand operations as shown in photos above. And only 2 parts are needed instead of 3. Why go through 5 hand operations when only 3 are necessary? Why handle 3 parts when only 2 are required? For an eye opener on the economies of the SPEED NUT system just multiply this 40% motion-saving by the millions of fasteners you use per month. Then add to that the saving by eliminating 1/3 of the parts. Your figures will amaze you. The winning products in postwar competition will be those

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F A S T E S T T H I N G S I N F A S T E N I N G S

Speed Nuts★
[PATENTED]

*Trademark Reg. U. S. Patent Office

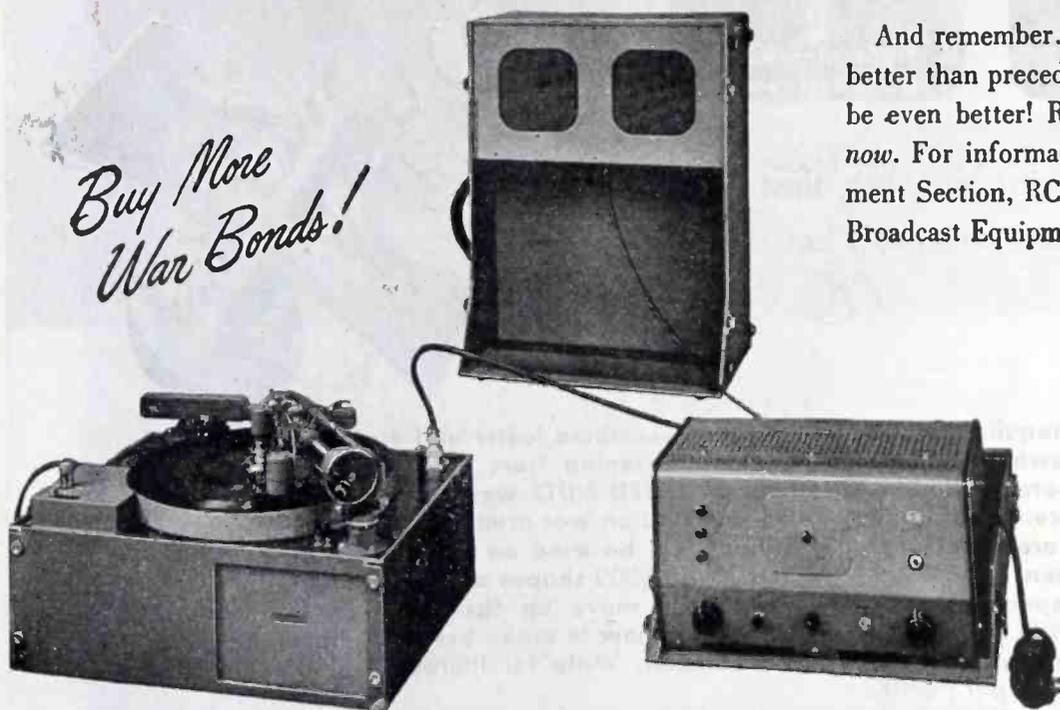
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Portable recording equipment. Model OR-1, economical in price, for good recordings in the studio or field. A complete recording channel consisting of a rim-drive turntable with standard recording and reproducing arms, an amplifier chain and a loudspeaker unit.

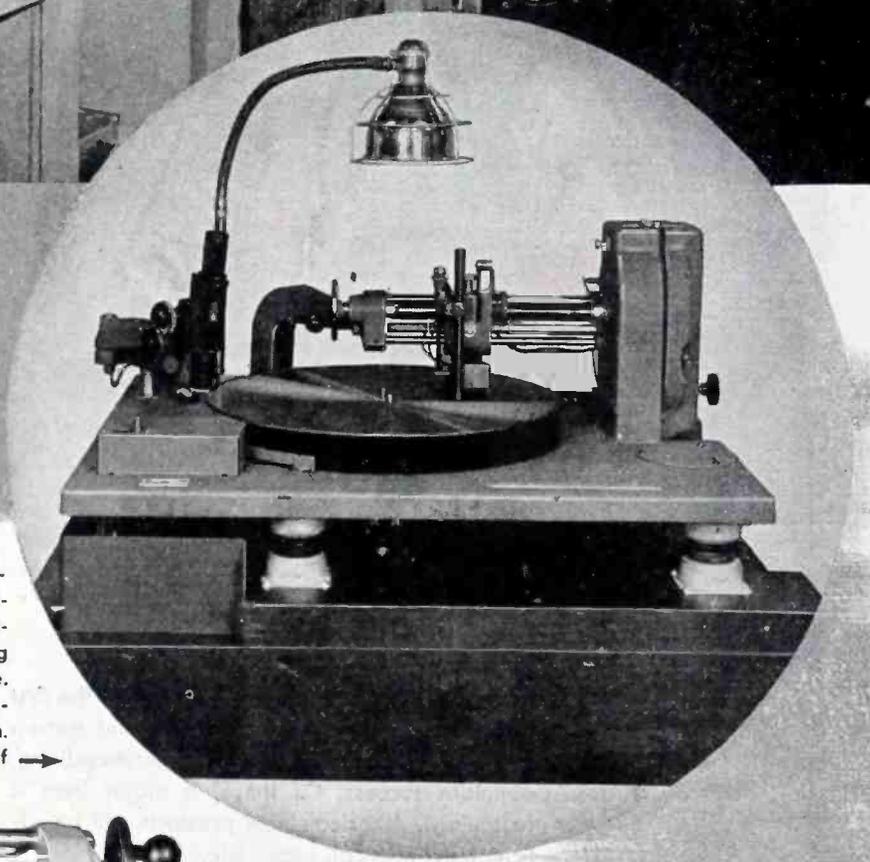
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RCA VICTOR DIVISION • CAMDEN, N. J.

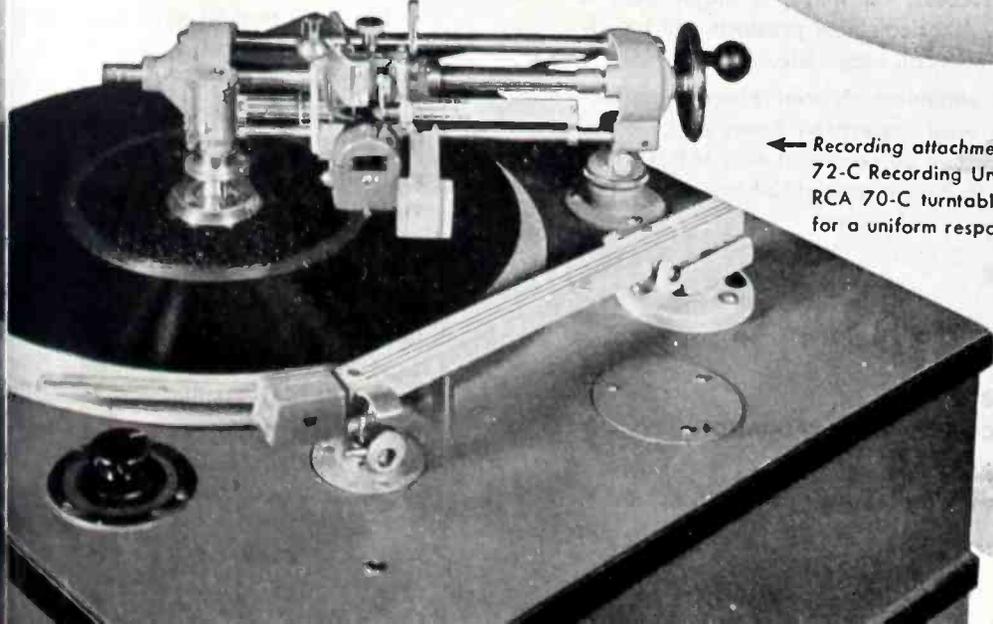




Featured here is the recording booth at OWI Headquarters, New York City. These RCA recorders are used in making transcriptions of OWI news and entertainment programs for overseas broadcasting.



Close-up view of the RCA recording model employed at OWI Headquarters. A professional-type unit, the 73-AX Recorder provides highest-quality, instantaneous recordings for broadcasting purposes. 30 to 10,000 cycle frequency response. Records at 33 1/3 or 78 r.p.m., outside-in or inside-out at 96, 112, 120, 136 or 154 lines per inch. Speed and groove adjustments at the turn of a knob. →



← Recording attachment for turntable mounting. The Model 72-C Recording Unit for control room use with standard RCA 70-C turntable equipment. Cutting head provides for a uniform response from 60 to 6000 cycles.

teepees were tied with thongs . . .



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heated the surface of each pin above its critical temperature in less than one second. At this speed of heating, there was insufficient time for the heat to penetrate into the core and only a thin surface layer experienced a change in physical state. The central portion of the parts retained all their original toughness and strength.

The factory application of this process to the continuous production line surface hardening of bearing pins involved the following equipment: the hopper from which the unhardened parts are fed into



Case-hardening of chromium-molybdenum steel bearing pins with a 5-Mc r-f generator. Inset at right is a micro-photo of the hardened surface. The white portion is the outside case which has a thickness of 0.025 in.

the glass tube; the heating coil; a Megatherm induction unit manufactured by the Federal Tel. and Radio Corp.; a connection providing a continuous flow of water for quenching, and a work table with suitable containers for hardened pins as ejected from the heating fixture.

The coil used in this bearing pin application contains five turns of small copper tubing wound in a single layer approximately 1-in. long by $\frac{1}{4}$ -in. in diameter. The coil is grounded and does not carry high voltage. It is exposed to continuous wetting by the water used for quenching.

The metal was chromium molybdenum steel NE-9442 and the surface hardness developed was Rockwell C 60—about file-hardness. The pins were finish ground prior to heat treating, and, after the hardening process, there was no scale or

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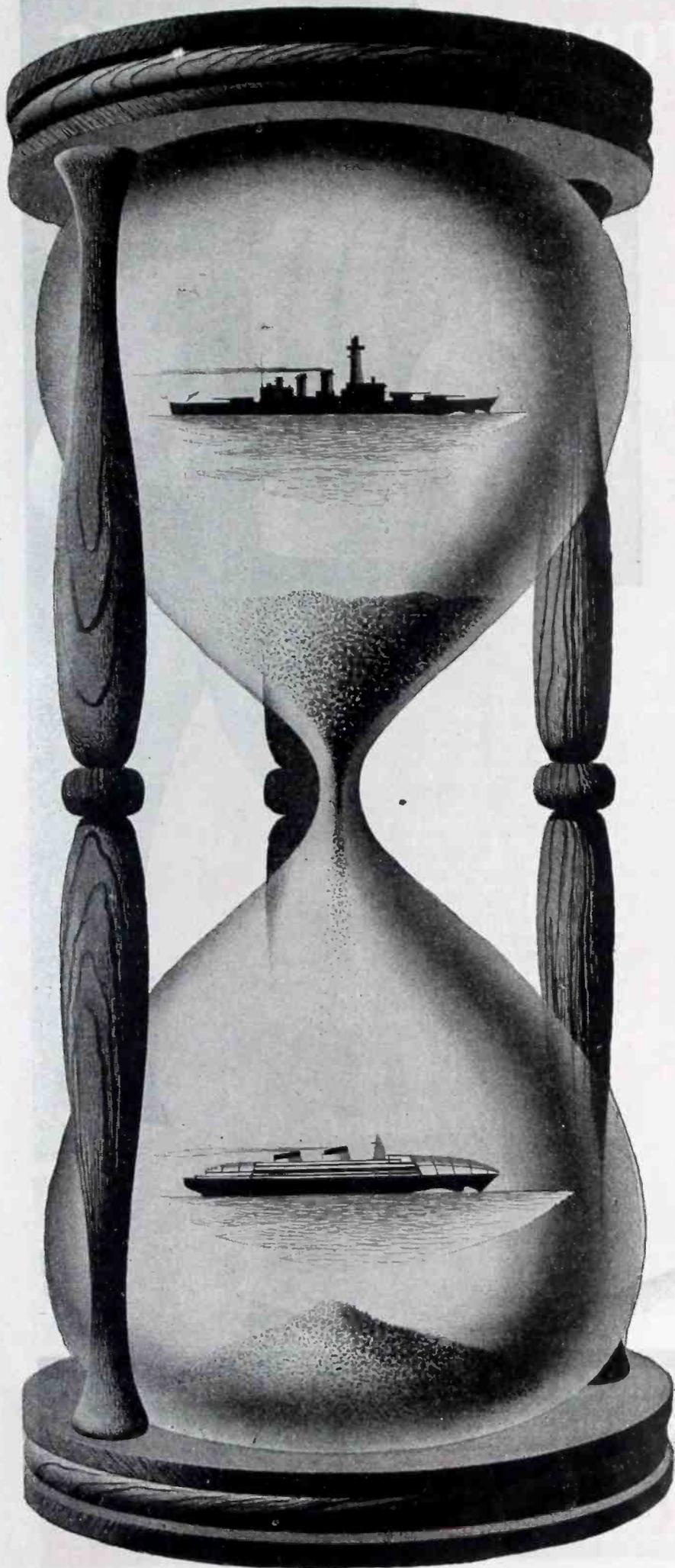
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Thermostatic Bimetals, Electrical Contacts, and Precious Metal Bimetallic Products are such important factors in the precision performance of ships, planes, tanks, guns, and various instruments of the Army and Navy that the H. A. Wilson Company has found it necessary to enlarge its facilities and develop these important new products and techniques.

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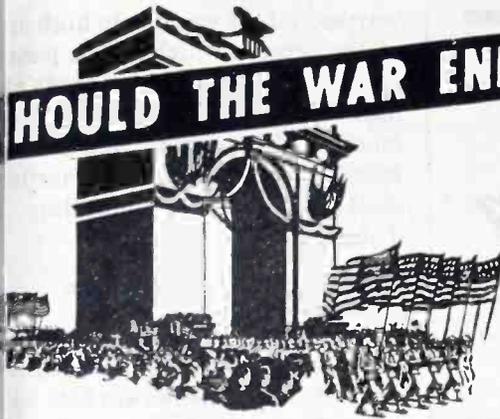
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Whatever the application—no matter how exacting the specifications—ELCO will deliver resistors as you want them—when you want them.

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SPECIFICATIONS:

"A-1"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—1/2% standard accuracy—non inductive pie wound—1/2 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A-R"—Same as A-1, with leads reversed.

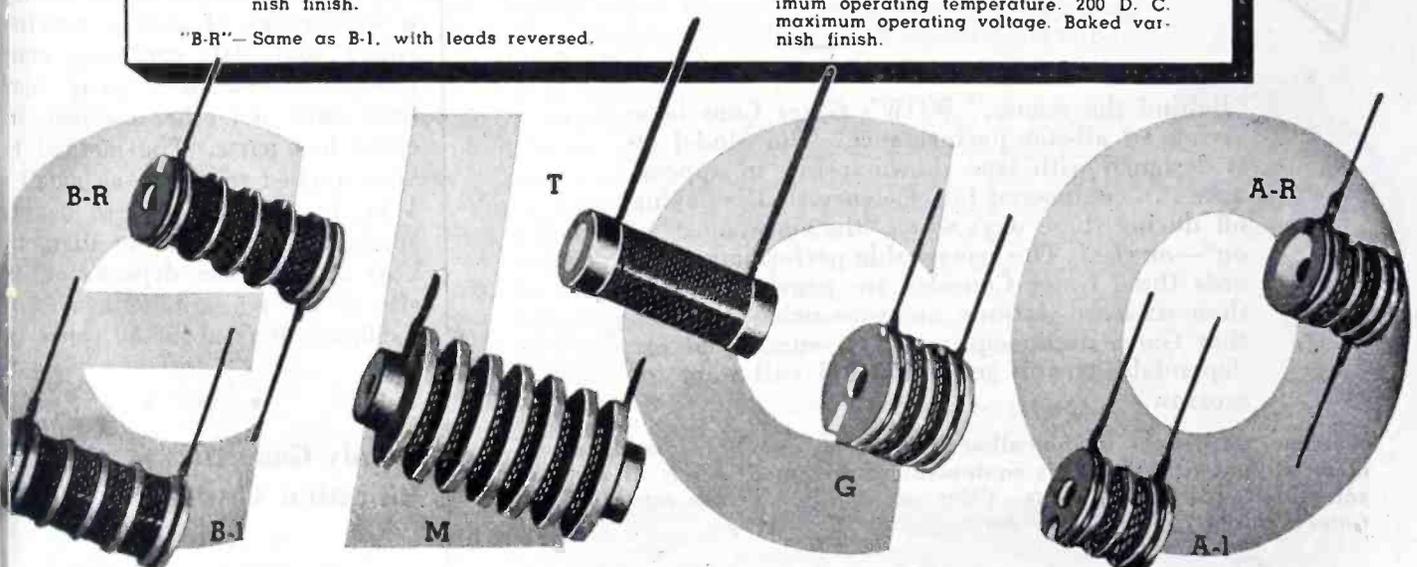
"B-1"—15/16 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—1/2% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—1/8 x .015 strap terminals—35 to 35,000 ohms—2 watts, 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

"M"—1-13/32 long x 1/4" dia.—Mountable with 6-32 screw—1/8 x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy Baked varnish finish.

"G"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. 1/2% standard accuracy—non inductive pie wound .8 watts, 30° temperature rise in free air, 100° C. maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.



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A WOW control operator shown
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Wartime restrictions do not allow the sale of new broadcasting equipment without priority. This equipment is presented merely to acquaint you with Gates developments. (May we send you details regarding the Gates Priority System for prompt postwar delivery?)

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RECORDING APPARATUS AND ALLIED EQUIPMENT IN THE ELECTRONICS FIELD

warpage. This was due to high speed of the process which makes possible the surface hardening of parts after finish grinding. This eliminates much costly finishing which heretofore has been required on hardened steel parts because of sealing and distortion.

Depth of Treatment

The microphotograph insert in the illustration shows a highly magnified view of the hardened surface as developed on the bearing pin. The white portion is that of the hardened outside case, and it will be observed that it extends a distance of 25 thousandths of an inch beneath the surface. Of this 25 thousandths, there is no visible change in the structure or depth of approximately 15 thousandths of an inch. From this depth in, there is a slight change in the apparent structure in the material, but there was no measureable loss of hardness insofar as was determined with a carefully conducted superficial Rockwell test. The dark portion is that of the unaffected core material. At no point in the transition zone from fully hardened case to the dark unaffected core material was there any evidence of softening or tempering of this adjacent internal layer.

The bearing pin application is only one of a family which includes a wide range of shafts, bearings, round and flat surfaces, zones, spots, cam surfaces, gear teeth, lever ends and other common machine tool parts. The method has been applied to pieces as small as $\frac{1}{8}$ in. in diameter and to bearing surfaces up to 6 in. in diameter. Cost of operation depends on the size of the r-f unit, with a 25-kw oscillator, it is about 50 cents per hour.

• • •

Handy Gage for Vibration Testing

By F. R. Jessop

Examiner 1/C Type Tests
Inspection Board of United Kingdom and
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BECAUSE ELECTRONIC EQUIPMENT for the armed forces must perform under the severest operating conditions, all production is subjected to vibration testing. The device to be described has proven very useful



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Electronic Connectors and Parts

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Engineers in these plants from coast to coast worked simultaneously in designing parts that would meet the requirements set. Each production department set up a time table of the dates on which it would make first and subsequent deliveries. And B-29 progressed by the clock.

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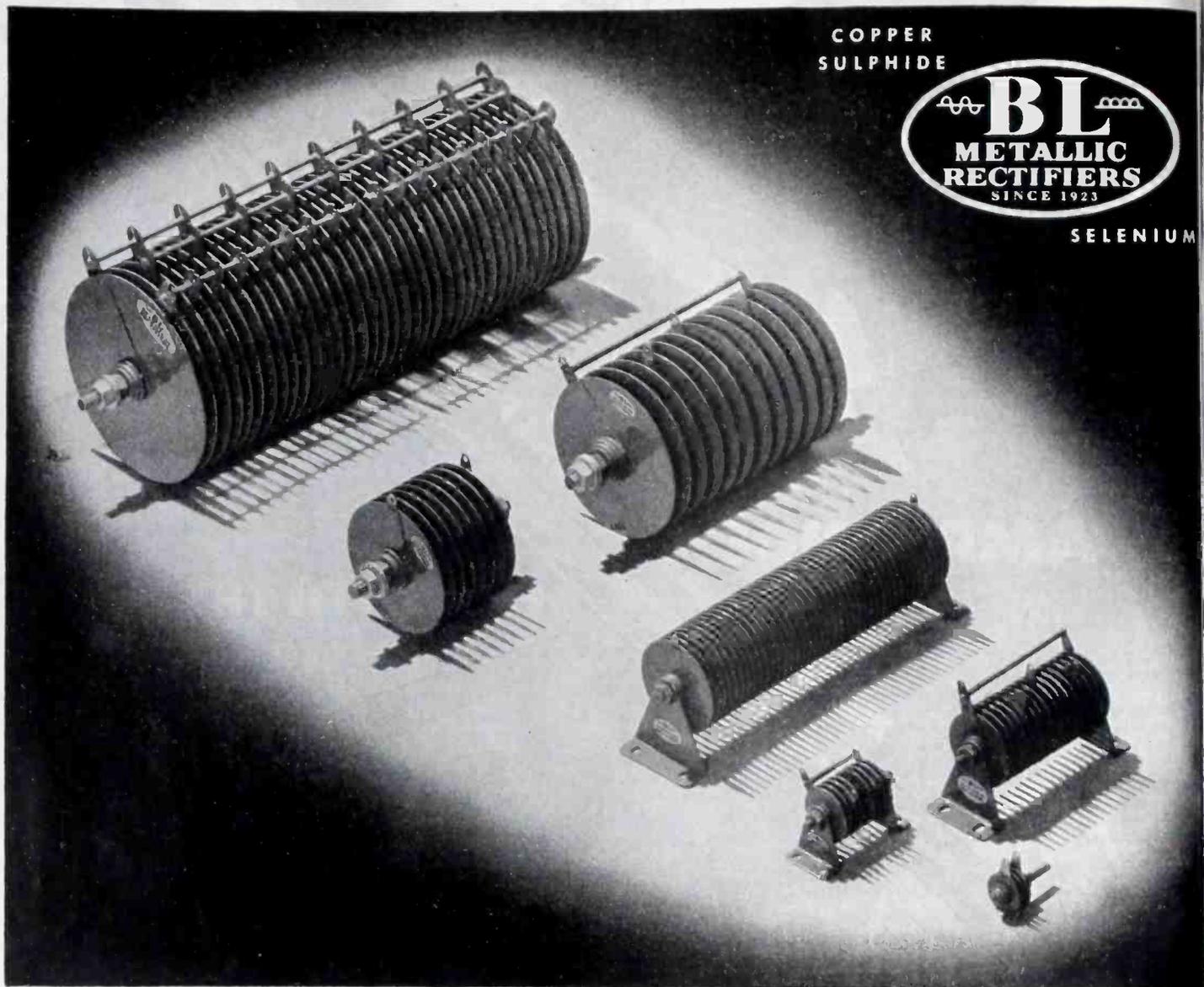
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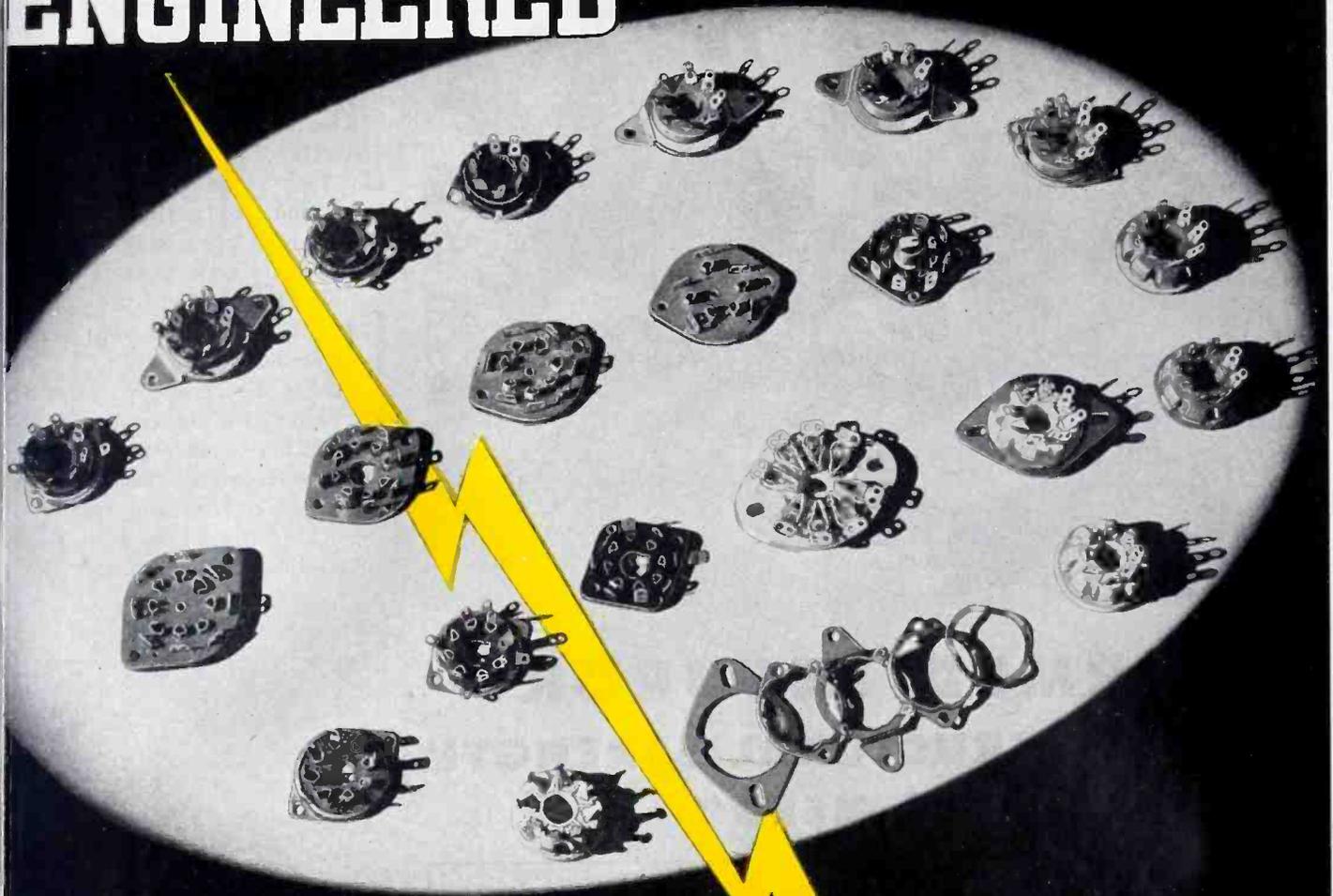
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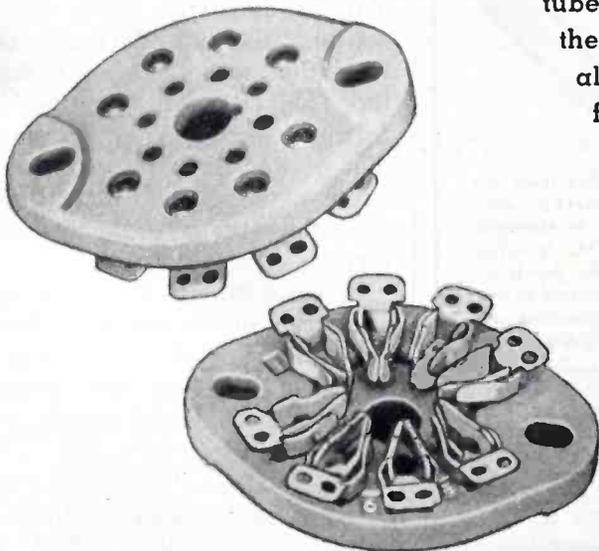
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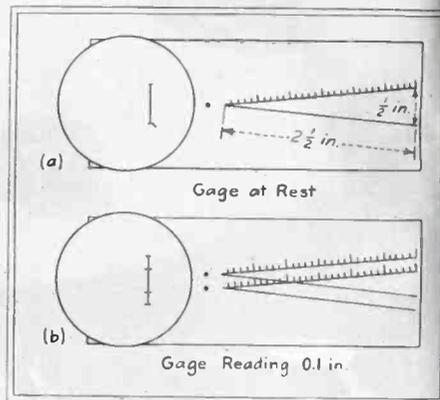
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for determining the direction of maximum displacement and to accurately measure that displacement to 0.005 in. It is especially useful when it is necessary to take measurements at various points of equipment when studying the effect of shock mounts.

The device consists of a small disc riveted at one end of a rectangular card as shown at (a) in the illustration. Both the disc and the rectangular piece may be made of stiff fiber, plastic or metal. The assembly is secured to the apparatus under test by means of scotch tape or other adhesive.

On the disc is drawn, slightly to one side of the center, a capital letter *I*. This is made equal in height to the extreme displacement to be measured during the test. When used in conjunction with a Strobotac, this letter indicates the di-



Gage for reading displacement of vibrating equipment and components. Made of fiber or plastic, it measures displacements from 0.005 to 0.3 in.

rection of maximum displacement. This is indicated when the two serifs of the letter *I* (made visible when the Strobotac is set at double the frequency of vibration) are farthest apart. The direction is that of the upright portion of the letter, as shown at (b) of the figure where the vibration is purely vertical.

In cases where the vibration is not purely in one direction, the upright will be double lines, but in the direction of maximum displacement, these lines will be closest together.

The small dot on the device is used to determine the frequency of vibration. This is obtained from the dial of the Strobotac when it is adjusted so that the dot is stationary. It is also useful to study the



HIS PROBLEM IS ALSO YOURS...

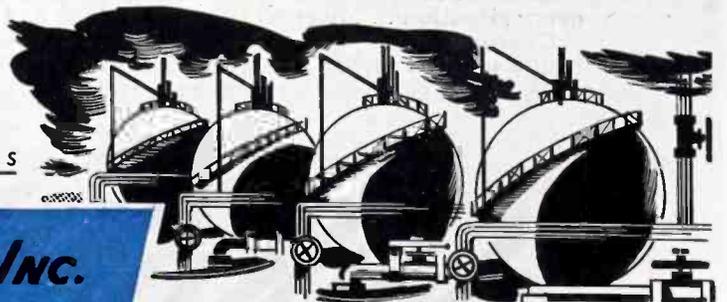
Right now he is looking for a target for one of his deadly "tin fish." But on his watch below he probably wonders what the postwar world back home will be like... and what kind of place it will have for him.

That's his problem... and ours, too. For Industry must be ready to absorb the boys as they are mustered out of the Service.

This means planning for conversion to peacetime production... designing new products... developing better methods and processes. The WPB has encouraged such thinking... has even released material for experimental and development work.

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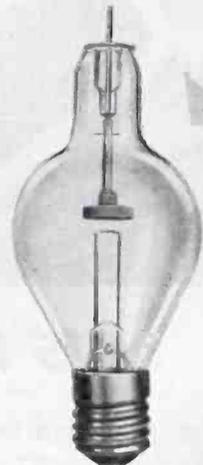
Particularly sensitive to blue and violet light. RMA spectral sensitivity designation S-4. 5-Pin base interchangeable with other similar tubes.



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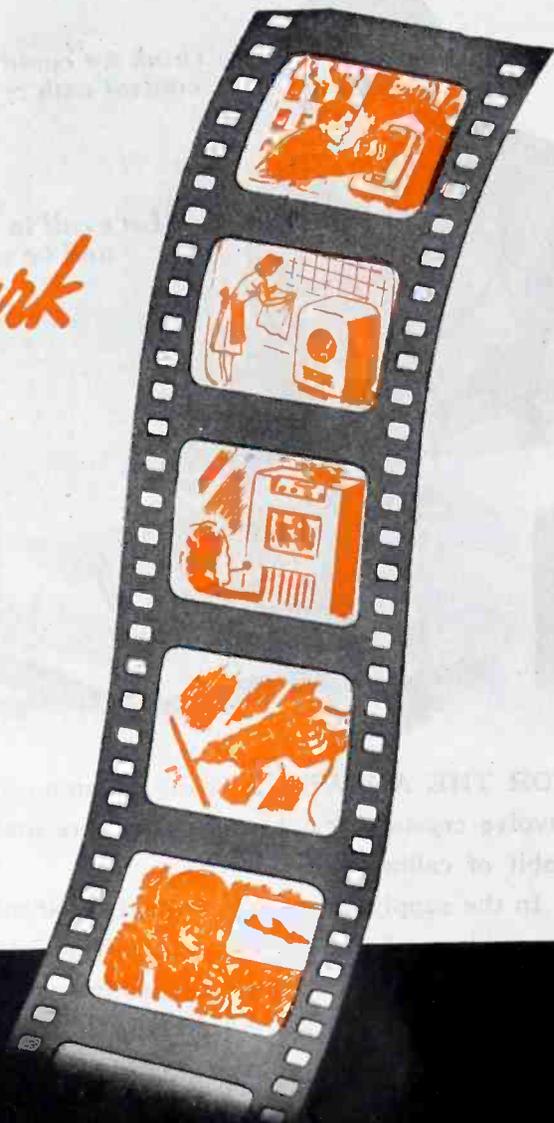
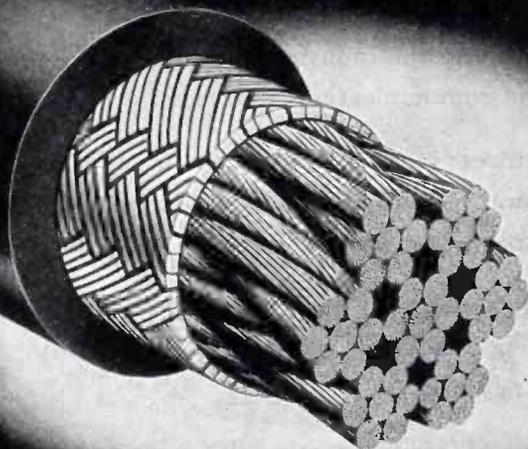
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This was possible only for these reasons:

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- 2 Crystalab testing equipment includes the finest instruments money can buy, plus many special instruments designed and built in the laboratory, to meet specialized needs.
- 3 Crystalab manufacturing equipment, most of it specially designed and built, is capable of producing crystals in any quantity, within the narrowest frequency tolerances.

Crystalab facilities are at your service, ready to help with your current or postwar-planning problems. If experienced help in electronic research, design and manufacture is your need, you will do well to . . .

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 **CRYSTAL RESEARCH LABORATORIES**
INCORPORATED
TWENTY-NINE ALLYN STREET, HARTFORD, CONNECTICUT

movement of the equipment which is being vibrated when the Strobotac is adjusted so that the dot traces the exact path of a vibration cycle.

Displacement Scale

The device also contains a drawing of an isosceles triangle with sides $2\frac{1}{2}$ in. long on a $\frac{1}{2}$ -in. base. This contains graduations $1/20$ in. apart on one side to provide displacement readings in which each small division is 0.01 in.

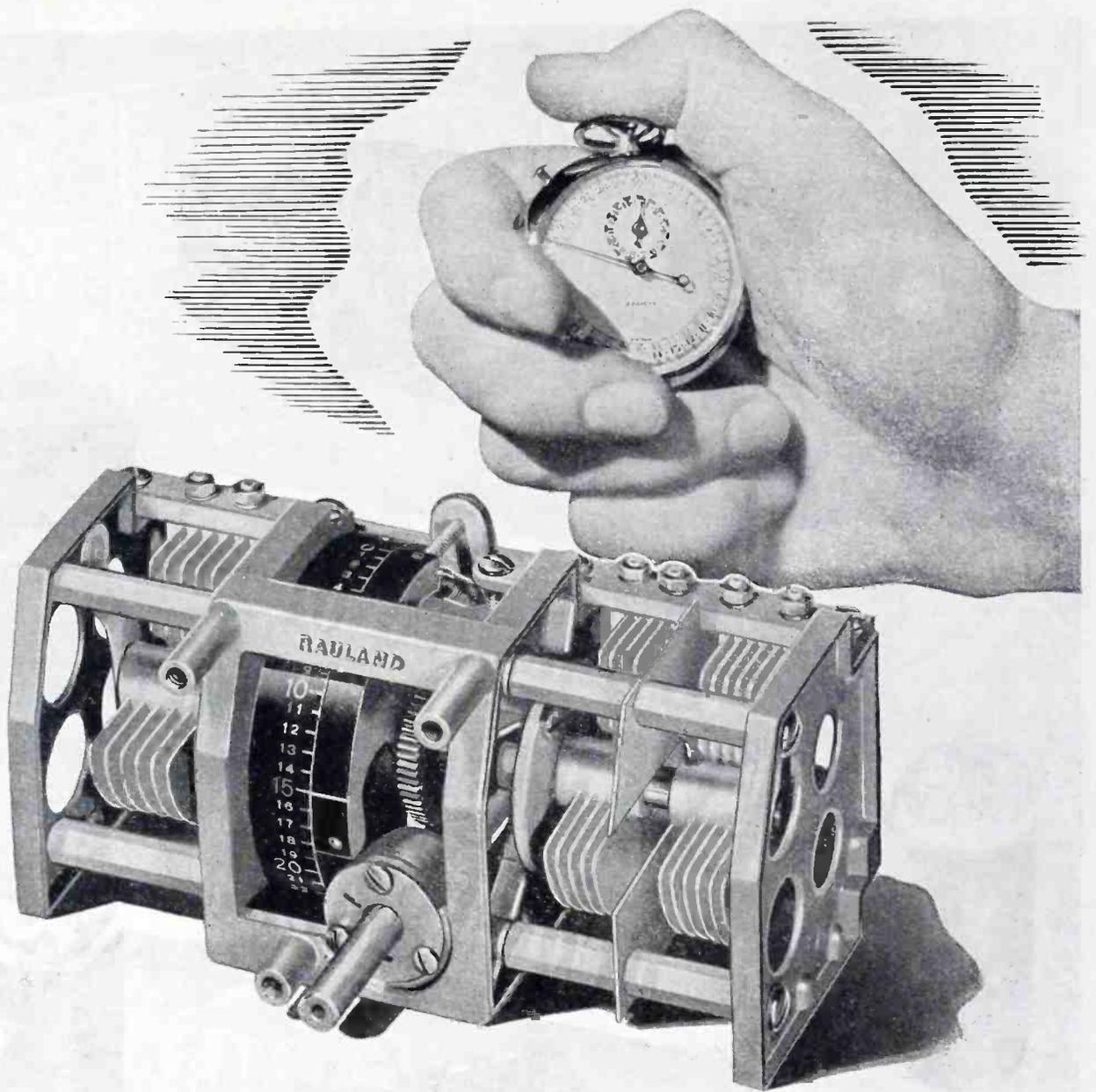
When this printed angle is observed with the Strobotac set at twice the frequency of vibration two complete angles will be seen as shown at (b) of the drawing. The reading is made at the point of intersection of one graduated line with one plain line. To read maximum displacement, it is necessary to mount the gage at right angle to the direction of this displacement as obtained by the rotating disc.

From the frequency reading obtained with the dot and the displacement reading provided by the angle, it is possible to calculate the acceleration G from the formula $G = 0.0511 d f^2$, where d is the total displacement in inches and f the frequency of vibration in cycles per second.

If the frequency of vibration is known, satisfactory readings can be made with the unaided eye, as the I on the disc gives a blurred effect which is readily observed and read in the same manner as with the Strobotac. The angle is also blurred and the reading is taken where the two blurred lines meet. When this method is used, observations of the exact displacement can be obtained even where it is impossible for the observer or instruments to be in a steady state, as all readings depend only on the speed of light for their accuracy.

While no attempt has been made to do so, it is believed that readings of much smaller displacements could be made by reducing the dimensions of the angle by photographic means and observing the readings by optical methods.

ALMOST 200,000 persons have been trained in radio occupations since July, 1940 under the vocational training for war production program.



...craftsmanship accuracy

The RAULAND Tuning Capacitor, shown here, is an excellent example of high accuracy in performance. Its sturdy, rugged construction is blended with a precision-accuracy which insures minutely controlled variations and a fine degree of tuning. RAULAND engineers and craftsmen take justifiable pride in their records for design and precision production of electroneered* communications equipment... advances which foreshadow wide application in the post-war world.

*Electroneering — the RAULAND term embracing engineering vision, design and precision craftsmanship.

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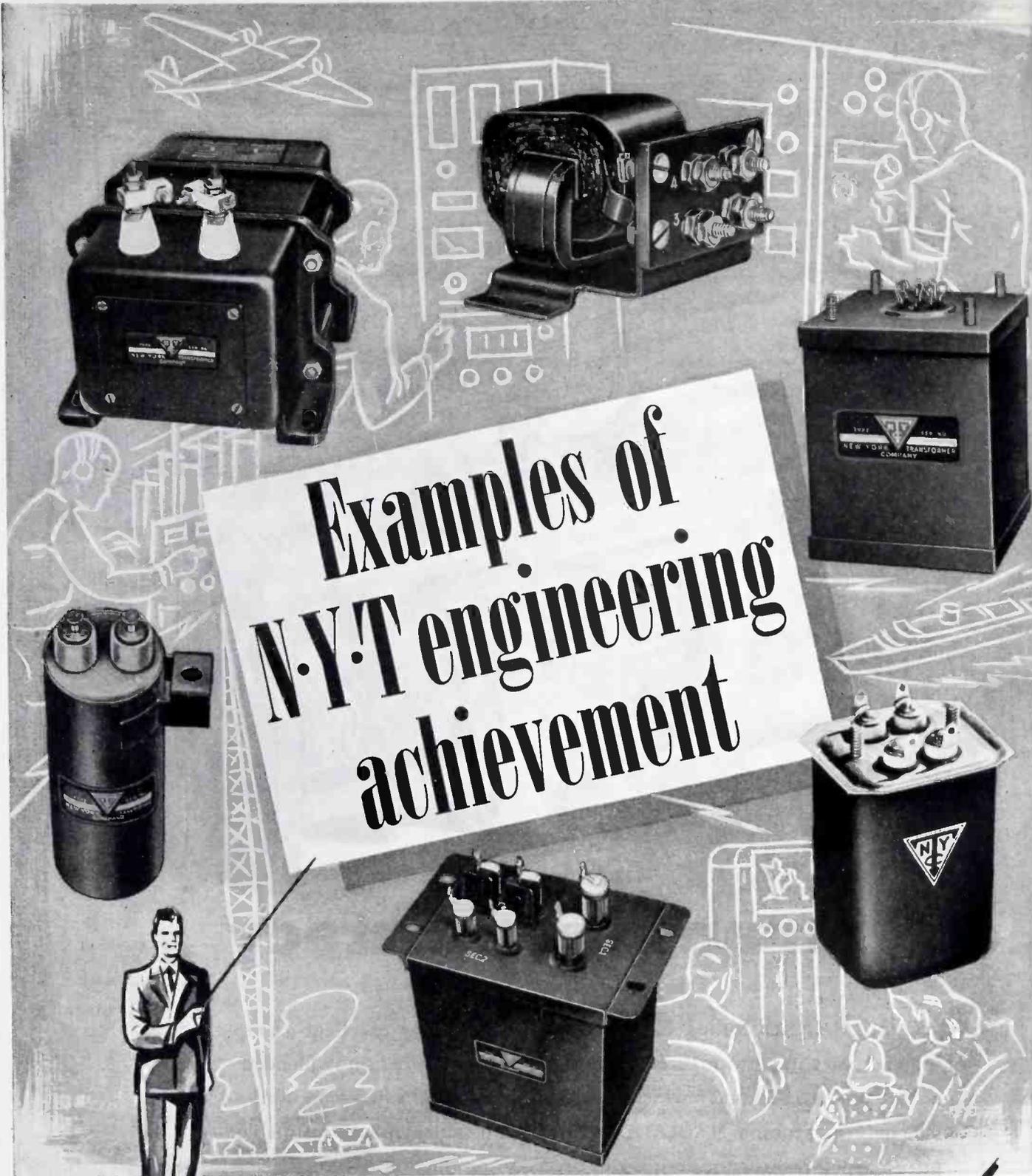
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Examples of N.Y.T. engineering achievement

.. which will make post-war products tick!



Out of the maelstrom of war—with its complex of electronic intricacies in communication, control, operation and guidance—have come these N. Y. T. transformer developments. Ranging from units for navigational aid to firing mechanisms, these N. Y. T. components are an integral part of the "sixth sense" of the Army, Navy and Air Forces. With the quickening tempo of war, and the casting of furtive looks by industry towards the post-war fu-

ture, the importance of transformer products with comparable accuracy, efficiency and dependability will be emphasized in civilian production. The acid tests of combat will be the proving grounds of tomorrow's simple household gadgets and industry's tools. N. Y. T. technicians can be instru-

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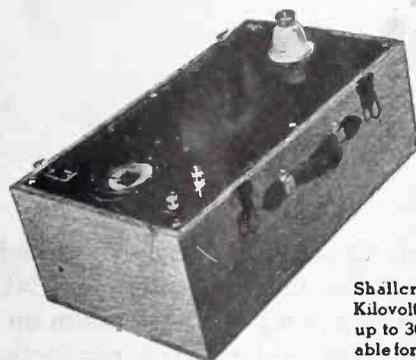
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DEPT. E-104, COLLINGDALE, PA.

ENGINEERING • DESIGNING • MANUFACTURING

Vibration Analyzer

(Continued from page 99)

the operation of the analyzer study should be made of the block diagram shown in Fig. 2. The electrical output of a pickup attached at some point on the engine or plane is a function of the vibration at that point. When a signal from the pickup passes through the analyzer circuit, one frequency component out of the complex wave is rectified and moves the pen of the recording instrument in a vertical direction by an amount proportional to the amplitude of the frequency component.

The output of an electrical transducer, which is coupled to the engine, is proportional in frequency and voltage amplitude to the engine speed. After the output of the transducer is amplified and rectified, it is caused to control the motion of the recorder pen so that it takes a specific position in the horizontal direction related to engine speed. Therefore, each curve drawn on the chart denotes the amplitude of vibration for one particular order of frequency as the engine speed varies over the entire range.

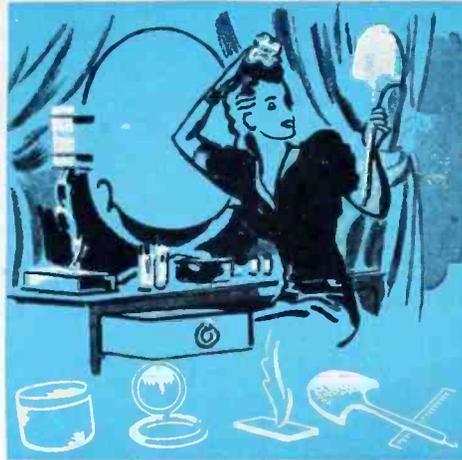
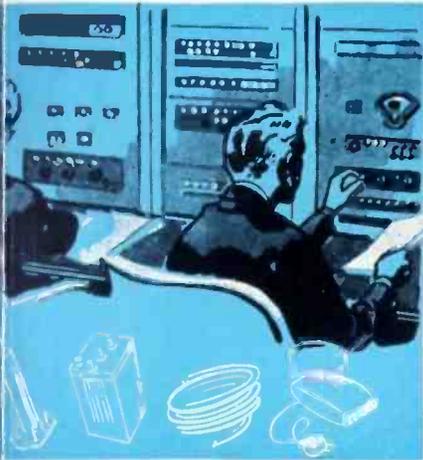
In view of the fact that the output of the pickup includes components at a number of different frequencies, it is necessary to provide a method of selecting some particular component and allowing only this one to control the action of the recorder pen. To accomplish this selection the output of the pickup is modulated by the output of an oscillator. The frequency of the oscillator is made to differ from that of the narrow-band filter by an amount equal to the component which it is desired to measure. The oscillator frequency is controlled by engine speed as indicated in Fig. 1.

To control the frequency of the modulating oscillator, a tuning capacitor is used which is operated by an electric motor. Simultaneously, this motor drives a potentiometer in a bridge circuit and each setting of the capacitor through the potentiometer is a corresponding setting of the bridge circuit. When the bridge circuit is in balance, driving voltage is applied to the motor. However, when the potentiometer setting is one that d



Why Plastic Plans Start with Polystyrene

Its outstanding properties . . . its huge production and consequent availability in the future . . . its low price . . . all these factors point to Styron (Dow Polystyrene).



To say that plastic plans start with Styron (Dow Polystyrene) is to make a big statement. But analysis of the plastics field shows it to be backed up by many factors—factors of far-reaching significance.

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You will want to know more about Styron—it is the plastic to keep your eye on. We'll be glad to send further details.

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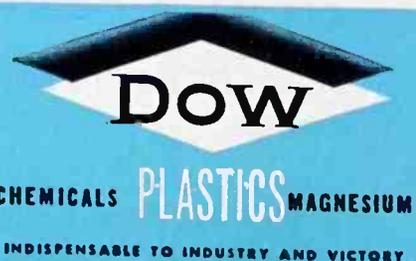
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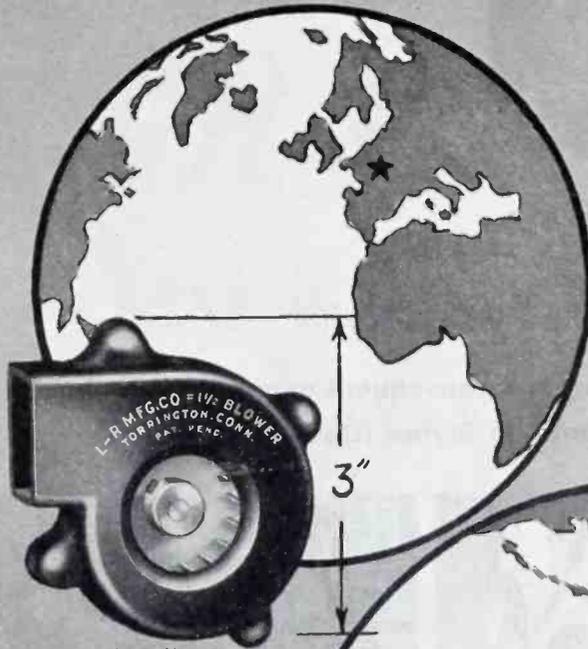
(DOW POLYSTYRENE)



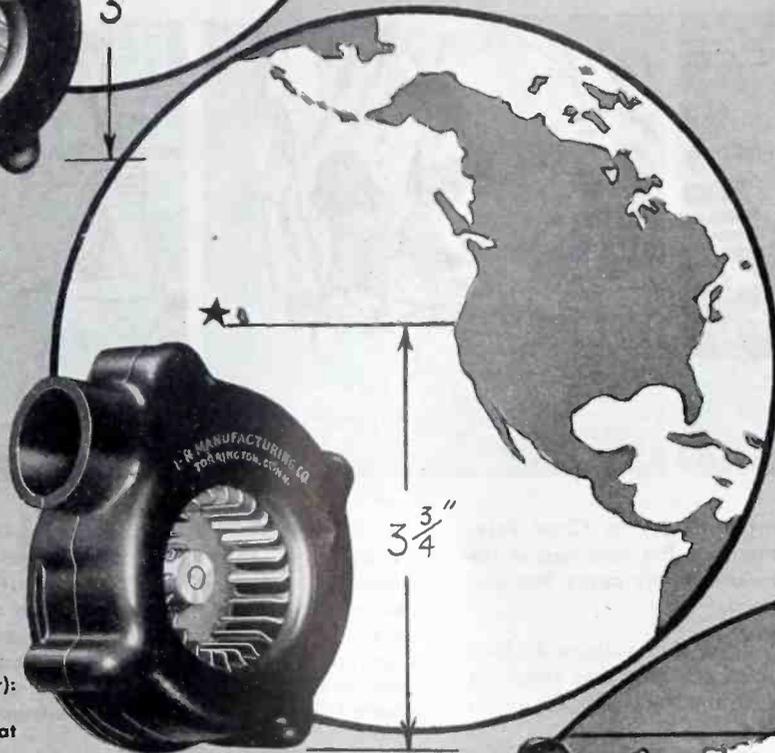
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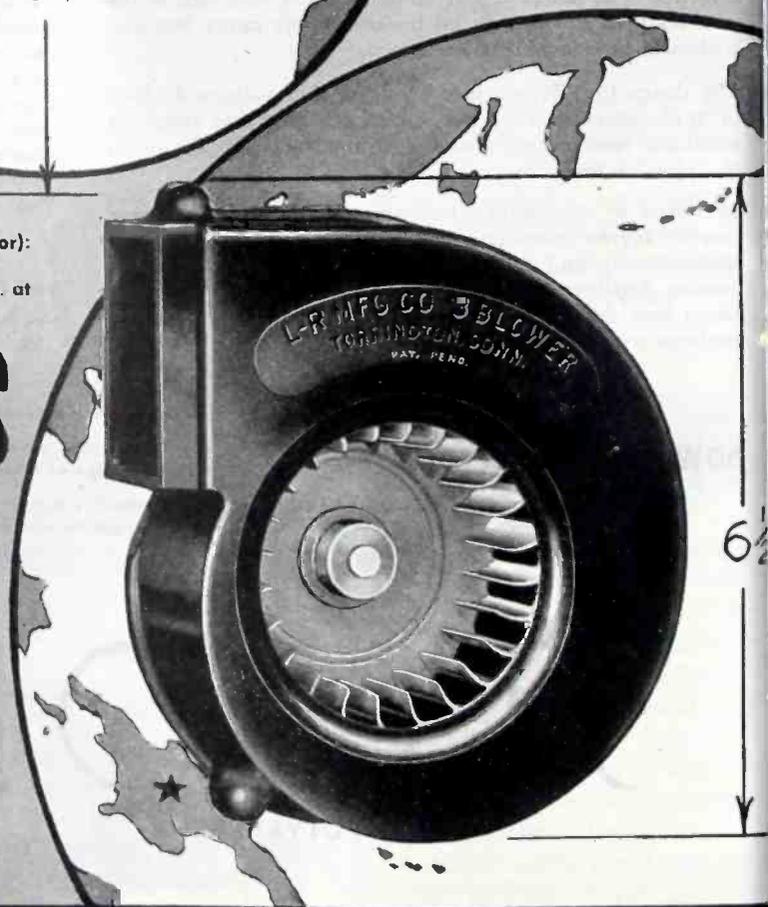


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8000 R.P.M.



Model 2
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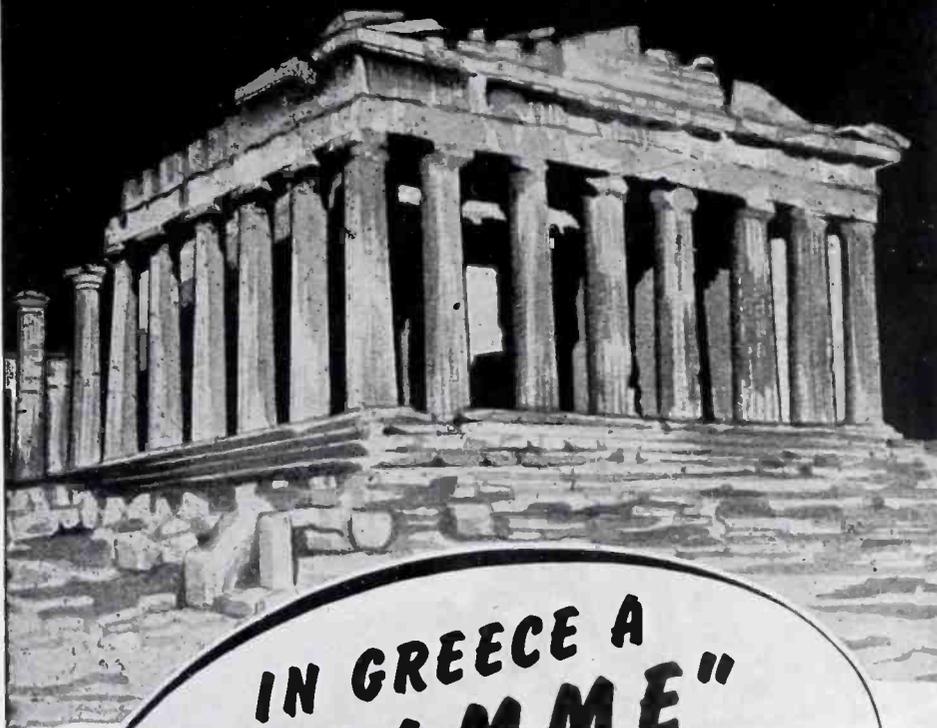
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When the requirements of war are satisfied to the degree that we can produce for peace . . . we will be ready with new ideas and new products to meet every accumulated need.

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not balance the bridge, then the motor will be driven in such a direction as to bring about a balance.

The potentiometer setting at which the bridge is balanced is different for each applied voltage and, as a result of the action of the motor when the bridge is unbalanced, both the potentiometer and tuning capacitor tend to be held at a position that corresponds to the voltage applied to the bridge circuit. The voltage applied to the circuit is the rectified tachometer voltage attenuated by a divider with 28 fixed positions. At each position the divider applies to the bridge circuit a voltage proportional to the engine speed multiplied by the selected order, and thus the K is the harmonic of the motor speed.

The design of the circuit is such that the oscillator has a frequency of $(92,000 + f)$, where f is equal to the particular frequency component to be measured. This convenient relation is attained by designing the circuit and tuning capacitor so that the capacitor setting is made proportional to the voltage applied to the bridge circuit; as pointed out in the preceding paragraph, this voltage is proportional to motor speed multiplied by the pre-selected order which in turn is proportional to the frequency to be checked.

The frequency f from the amplified output of the pickup modulates the frequency $(92,000 + f)$ from the oscillator in the modulator circuit arranged to balance out the oscillator frequency. Thus, the two chief components in the modulator output are the sum and difference frequencies.

The output of the modulator is connected to a crystal-type filter which has a pass band at 92,000 cps that is only 4 cycles wide. By means of this filter the 92,000-cps side band is readily passed while the other side band is rejected. This signal is then mixed in the demodulator circuit with the output of the same oscillator, with the chief components of this second modulation being the carrier frequency and the upper and lower side bands. The high frequencies are easily rejected and after the frequency f is rectified it is passed to the recorder to control the position of the pen.

The main elements comprising the automatic frequency analyzer are a tachometer, small control box

AMERICAN Phillips SCREWS

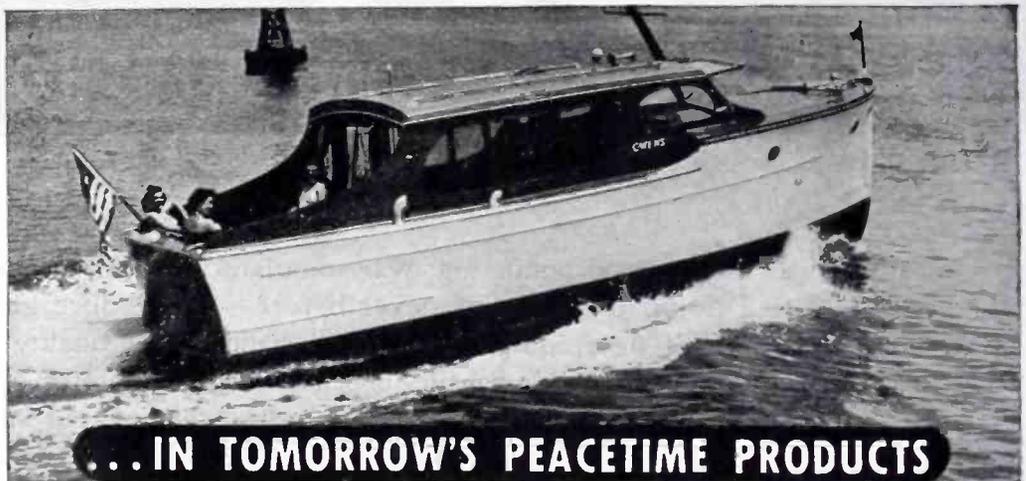
for Top Speed and Lowest Cost of Assembly



...IN TODAY'S WAR EQUIPMENT

In the U.S. Army crash boats (shown above) and landing barges built by the Owens Yacht Company of Baltimore, American Phillips Screws are used to make *speedier, stronger fastenings* . . . to get these vitally needed craft into service quicker, and to make sure they will stand up to the strenu-

ous service required. Owens workers, using power drivers, make clean and flush fastenings right down the line, with American Phillips Screws. No fumbling starts, no crooked driving, no gouged work-surfaces, no split screw-heads. This is typical American Phillips Screw performance.



...IN TOMORROW'S PEACETIME PRODUCTS

Owens Yacht Company's peacetime pleasure craft, like their present-day war craft, will feature sturdy, ship-shape fastenings made by power-driven American Phillips Screws. In fact, the matchless speed and controlled accuracy of American Phillips fastenings will help this well-known boat builder to meet the pent-up,

urgent demand for his quality product . . . and still maintain his rock-bottom cost per fastening. In fact, in all fields of peacetime production, the production advantages of American Phillips Screwdriving will continue to be just as important as they were in meeting wartime delivery schedules . . . on time and with the inspector's OK.

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KEY to the successful development of PLASTIC products

The Ever-Lok Cord Connector with its metal collar precision molded-in has the strength and perfect fit necessary to meet the stringent requirements of industrial power systems.

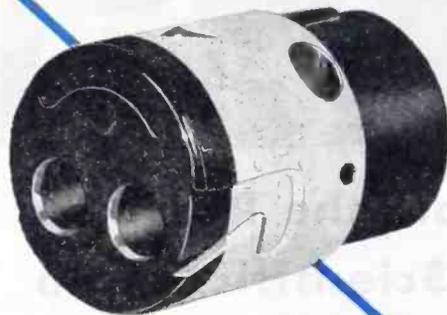
* * *

To the designer and manufacturer of electrical products, this case history is of unusual interest because it serves as an ideal illustration of the basic formula that is the key to the successful development of all plastic products. Essentially this formula consists of (1) proper design, (2) a plastic that fits the job, and (3) custom molding. In the development of the cord connector, this mold design was worked out (see diagram).

The groove (A) in collar (B) is extended into the plastic body (C) to form a funnel shaped groove for locking and balanced support of the plug. Holes (D) for assembling interior connections are molded at right angles to holes (E). Slight indentations are molded to mark positive and negative terminals (F). White enamel wipe-ins are placed in holes (G) which hold the connector in its shell. Rib (H) holds the connector in correct position in the shell.

The correct choice of molding material presented an unusual problem because a molded-in metal collar undergoes a certain amount of expansion during the molding process and contraction upon cooling. So the plastics compound used must be capable of

absorbing this expansion and contraction without cracking. In addition, it must possess all the properties required of the finished product such as



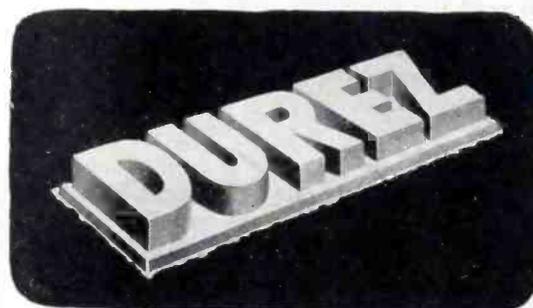
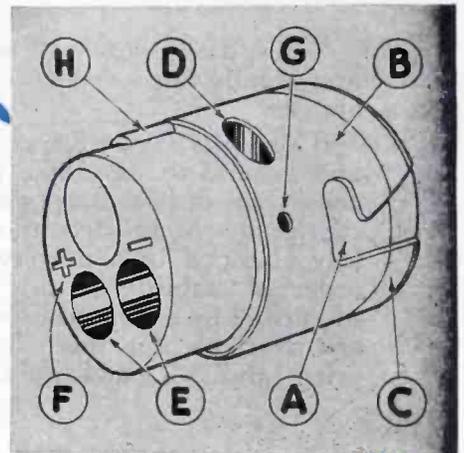
dielectric strength, resistance to impact, moisture, and heat.

From among the more than 300 versatile Durez molding compounds was selected a phenolic base material that met every requirement.

In molding this cord connector, the custom molder (American Insulator Corporation) used the transfer method—a process whereby the phenolic compound is subjected to heat and pressure and then forced into the molding cavity where it is shaped and cured.

This technique was selected because it permits speedier molding and insures accurate placement of inserts.

Durez technicians and service engineers have played a big part in many of the new developments to date. This wide experience equips them to be of valuable aid. They will be glad to give their assistance at any time in helping your product designer and custom molder work out any plastics materials problem. Durez Plastics & Chemicals Inc., 810 Walck Road, N. Tonawanda, New York.



PHENOLIC MOLDING COMPOUNDS AND RESINS

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analyzer unit with the tuning capacitor drive attached to it and the recorder. Additional equipment required includes the necessary power-supply units and amplifiers for the capacitor drive unit and recorder.

Method of Use

During a test flight, the control unit and recorder are the only parts of the equipment that require attention. On the panel of the control unit are two meters, one of which registers the amplitude of the measured signal while the other indicates the engine speed. Thus an operator may immediately observe any abnormally large vibration and the speed at which it occurs without reading the recorder. The panel is also provided with a frequency selector with which the order to be measured is selected. Also, to permit vibrations of very large amplitude to be kept within the range of the recorder and indicating meter, an attenuator is provided in the signal input circuit of the analyzer. A potentiometer which determines the voltage applied to the control device of the tuning capacitor during calibration, and four controls for calibrating the set, are also provided on the panel.

Results obtained by the use of the analyzer are being utilized by designers of aircraft engines in the gradual elimination of parts failures caused by excessive vibration.

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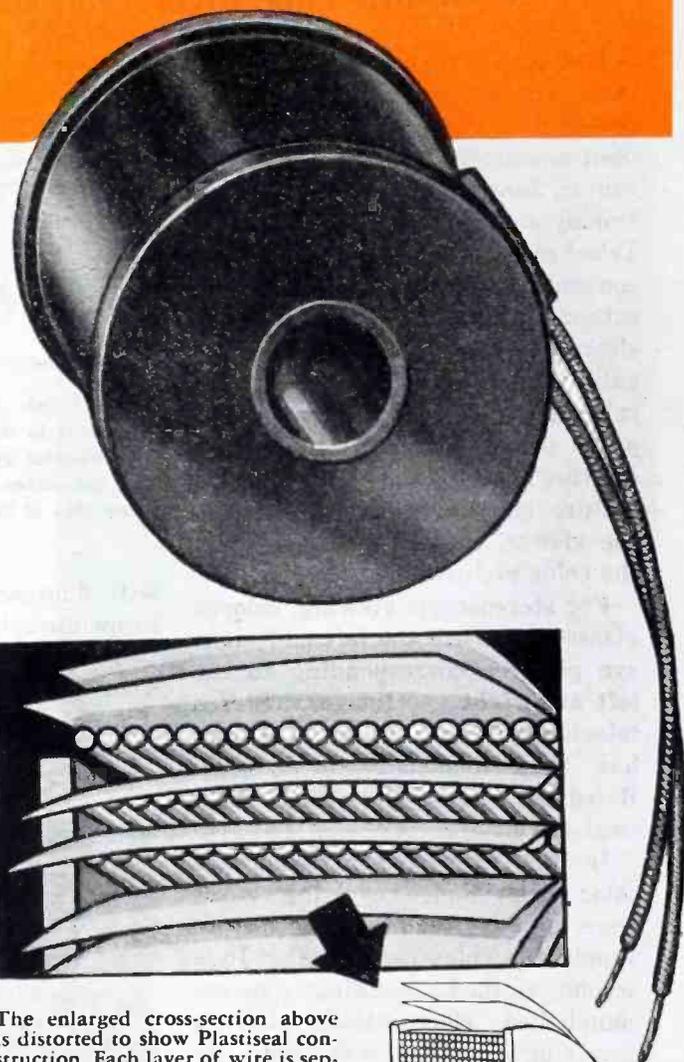
These coils are built up of sealed layers of Lumarith* (cellulose acetate) which is chemically inert under the conditions met within the coil. No paper, wax, varnish or glue is present—nor any other material which might permit electrolysis to occur and corrode the winding. The edges of the cellulose acetate are coalesced by a special process with the end washers, resulting in a complete seal. No impregnation whatever is needed.

Even in the presence of moisture and direct current, Plastiseal Coils have exceptional resistance to corrosion. Appearance, mechanical strength and insulating qualities are outstanding.

Plastiseal Coils are one of the many fine *engineered* products of Anaconda. Any of our sales offices will be glad to refer inquiries to our coil engineering staff.

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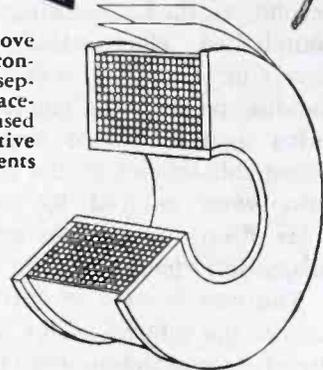
44236



The enlarged cross-section above is distorted to show Plastiseal construction. Each layer of wire is separated by a sheet of cellulose acetate, the edges of which are fused to the end washers. This protective construction effectively prevents corrosion.



Magnet wire and coils



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TUBES AT WORK

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New Baird Tube Gives Television in Color

COLOR AND STEREOSCOPIC pictures that appear directly upon the screen of a cathode ray tube have been announced by the English inventor, John L. Baird. The system employs a new tube called the Telechrome which differs from the conventional black and white cathode-ray tube in that it has two electron beams and a transparent double-sided screen. One cathode-ray beam produces a blue-green picture on the front surface of the screen, the other a red picture on the back surface. To the viewer, the two blend to form the color picture.

For stereoscopic viewing, colored glasses are used, the left and right eye pictures corresponding to the left and right eye images. Stereo television without the use of glasses has been demonstrated by Mr. Baird but has not been made practical as yet.

In his first demonstration of color television, revolving discs were used for scanning and also to supply the color component. In a second method, scanning was accomplished electronically and a revolving color disc was used. No moving parts were employed in a third system where images produced side by side on the face of the tube were colored by stationary color filters and superimposed by projection upon a viewing screen.

The new system is entirely electronic, the colored image appearing directly upon the fluorescent screen. Two cathode-ray beams are required for a two-color system and three for a three-color system. The beams are modulated by the incoming signals corresponding to the primary color picture and impinge upon superimposed screens coated

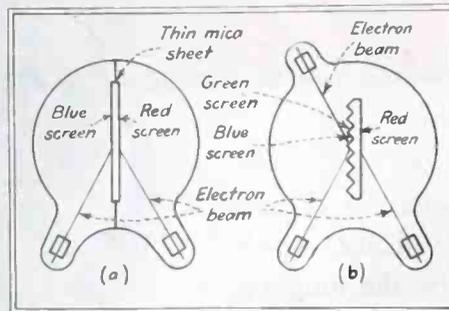


FIG. 1 (a)—Arrangement of phosphor coatings in the new television tube for a two-color system. (b) A ridged back on the screen provides two surfaces on one side of the screen for a three-color system

with fluorescent powders of the appropriate colors. For example, in a two-color system, the two beams scan the opposite sides of a thin plate of transparent mica one side of which has been coated with

orange-red fluorescent powder and the other with blue-green fluorescent powder. The construction of this type of tube is shown at (a) in Fig. 1. Thus the screen has formed upon its front face an image containing the orange-red color components and on its back face an image containing the blue-green components, these images are superimposed to give a color picture.

Three Colors

Where three colors are to be used, the back screen is ridged as shown at (b) in Fig. 1, and a third cathode-ray beam added; the front face of the screen giving the red component, one set of sides of the back ridges giving the green components, and the other sides of the ridges the blue component.

A two-sided tube has been developed that produces a picture from a 600-line, triple-interlaced moving-spot transmitter using a cathode-ray tube in combination with a revolving disc with orange-red and blue-green filters. The receiving cathode-ray tube is shown in the diagram of Fig. 1 and in the photograph of Fig. 2. The screen is a 10-in. diameter disc of thin mica coated on one side with blue-green fluorescent powder and on the other with orange-red fluorescent powder. The color may alternatively be pro-

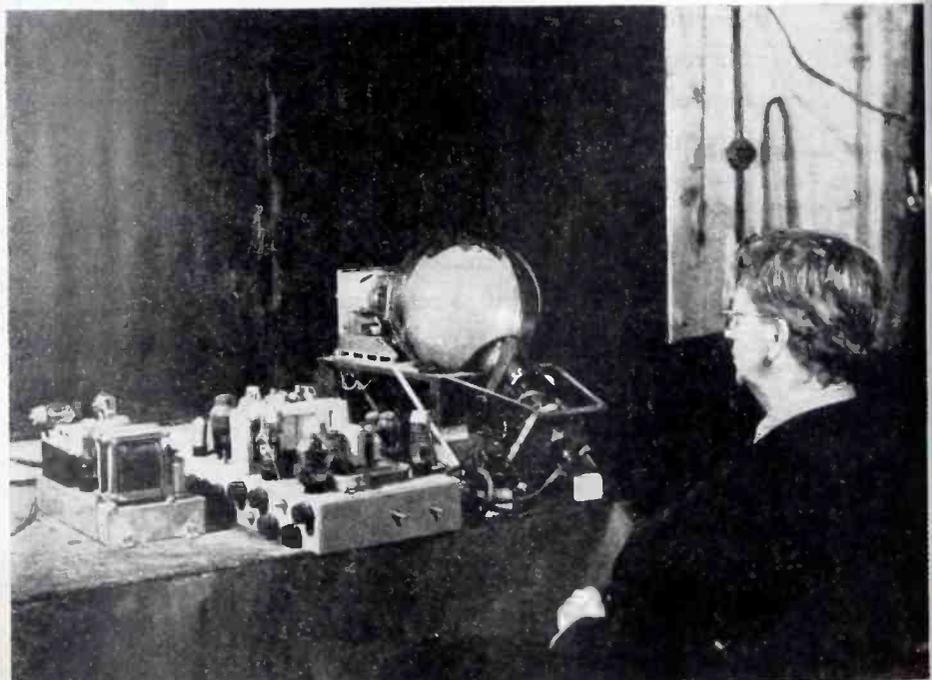


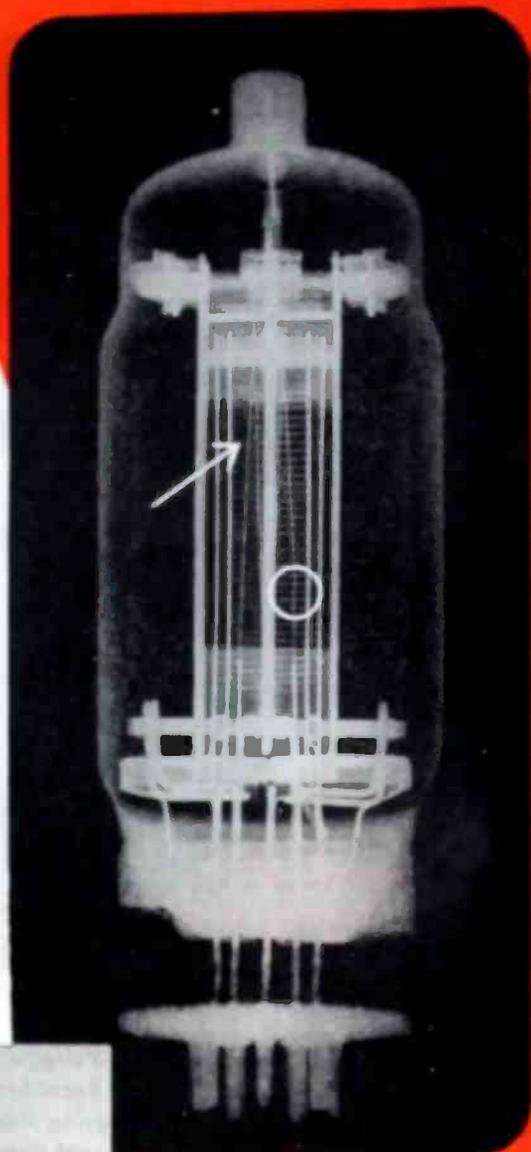
FIG. 2—Complete receiver for color and stereoscopic television with the Telechrome, a new cathode-ray tube invented by John L. Baird, noted English television engineer

Why *Norelco* Tubes give uniformly high performance

Inspection by X-ray is only one of the many rigid tests applied to NORELCO electronic tubes. Misalignment of elements and similar internal faults, which cannot be seen by clear visual inspection, may still permit a tube to function. Spot radiographic inspection by Searchray guards against such "invisible" defects creeping into production runs, thus assuring tubes of high performance and long life.

Typical of the thoroughness of our inspection methods on certain tests is the use of Searchray, the self-contained, rayproof, shockproof, easily operated industrial X-ray apparatus designed and developed by North American Philips. In keeping with this organization's traditional watchfulness over the quality of its products, we make our own X-ray tubes, as well as fine wire for tube manufacture and diamond dies for our own fine wire drawing. These many tests and exacting quality control are reasons why NORELCO electronic tubes, with their consistently uniform characteristics, high performance and long life, should be your choice for postwar industrial use.

Although all the tubes we produce now go to the armed forces, we invite inquiries from prospective users. A list of tube types we are especially equipped to produce will be sent on request.



Unretouched radiograph of a defective NORELCO Type 813 tube taken by a NORELCO Model J50 Searchray, showing fractured filament and, on the left side, a misalignment of control and screen grids, as revealed through the surrounding graphite plate.



A NORELCO Type 813 Beam Power Transmitting Tube.

Send you our booklet telling the story of North American Philips. Behind this company is a team of outstanding electronic engineers, headed by one of America's leading physicists, and coached by a group with world-wide experience resulting in a fifty years of research and development. Today we work for Victory; tomorrow, our aim is to serve industry.

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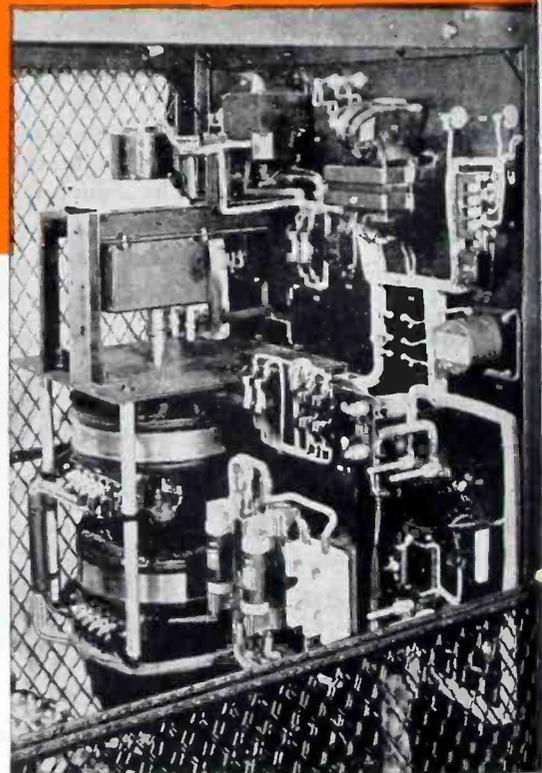
AMERTRAN HIGH VOLTAGE TEST SETS



Retain Calibration
Reduce Manual
and
Visual Errors

Improved reliability of AmerTran High Voltage Test Sets is readily apparent under operating conditions. Recalibrating intervals are usually lengthened—a substantial time saving that results from combining precision and sturdiness to an unusual degree. This sustained accuracy wins operator confidence, as do the positive acting, easily manipulated controls and quickly read dials. Built-in safeguards protect both operator and equipment. An important advantage is their versatility—multiple secondaries allow quick output range adjustments within which Transtat Regulators provide close control in small voltage increments.

Comprising many models, AmerTran High Voltage Test Sets have ample facilities for all kinds of dielectric and general testing involving voltage application of any required duration. Into each unit goes the same craftsmanship that has made AmerTran the standard for electrical testing in leading industries, utilities and universities since 1901. Write for complete details.



THE AMERICAN TRANSFORMER COMPANY
178 EMMET STREET
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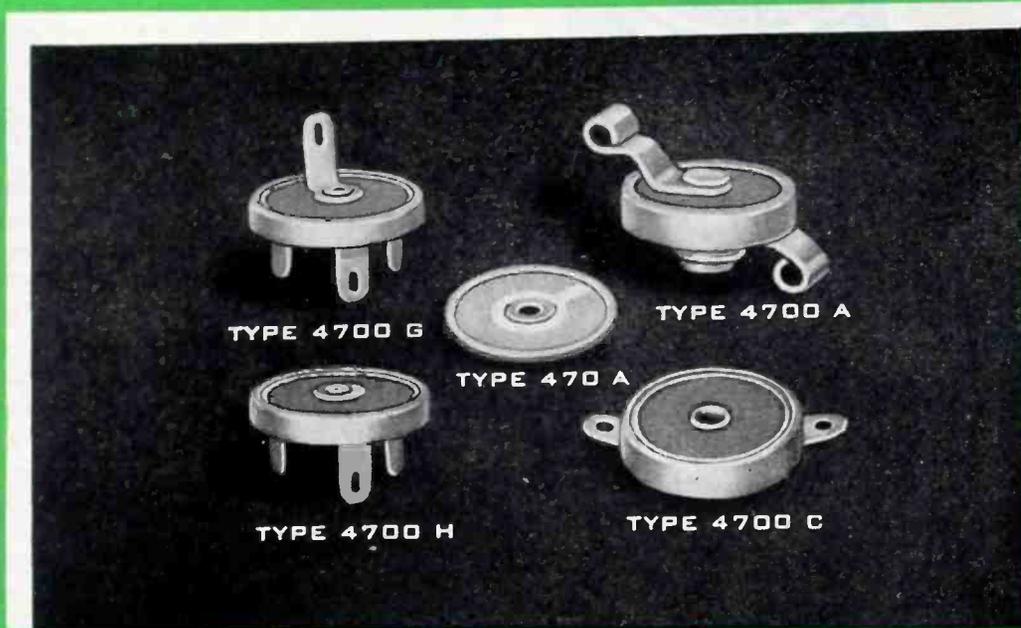
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of Transformers, Reactors
and Rectifiers for Electronics
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AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.



Compact • Efficient • Time-Tested



Erie Button Silver Mica Condensers

THE efficiency, quality and practical application of Erie Silver Button Mica Condensers has been thoroughly proven since 1942.

These small condensers consist essentially of a stack of silvered mica sheets encased in a silver plated housing. The housing forms one terminal, the other terminal being connected to the center of the stack, thus providing the shortest possible electrical path through the capacitor.

Types 470 and 4700 have comparatively high capacity ranges and their compactness, together with the wide selection of terminal mounting designs, for by-pass applications, makes them ideal components for V. H. F. and U. H. F. applications, where short ribbon-type leads and low series inductance are prime requisites.

Capacity ranges and electrical characteristics are shown at right.

Samples will be sent to interested engineers on request.

CHARACTERISTICS

CAPACITY RANGE:

- Type 470 A — 100 MMF to 1000 MMF
- Type 4700 A — 500 MMF to 3000 MMF
- Type 4700 C — 500 MMF to 3000 MMF
- Type 4700 G — 500 MMF to 2000 MMF
- Type 4700 H — 500 MMF to 2000 MMF

INITIAL POWER FACTOR:

.12% Maximum @ 1 Mc. and @ 25° C.

WORKING VOLTAGE:

- 500 Volts DC
- 350 Volts AC

TEST VOLTAGE:

1000 Volts DC

INITIAL LEAKAGE RESISTANCE:

Greater than 10,000 Megohms @ 25° C.



Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND • • TORONTO, CANADA

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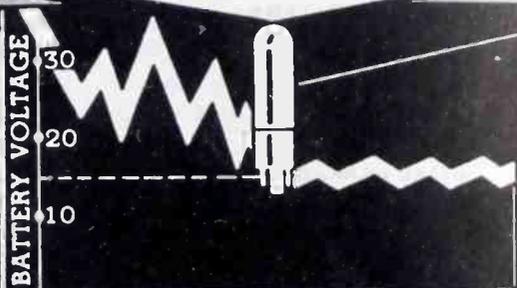


PETERSEN RADIO CO.

Council Bluffs, Iowa

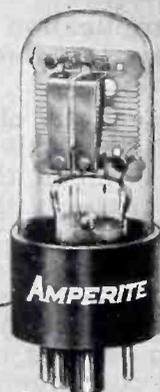
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- Used by U.S. Army, Navy, and Air Corps.

DELAY RELAYS: For delays from 1 to 100 seconds.
Hermetically sealed. Unaffected by altitude. . . Send for catalogue sheet.

NEW! 4-page folder will help you solve Current and Voltage Problems: contains much valuable data in practical form — Write for your copy now.

AMPERITE CO., 561 Broadway, New York (12), N. Y.

In Canada: Atlas Radio Corp., Ltd., 560 King St., W. Toronto

vided for the back screen by using a white powder and coloring the mica itself.

The tube shown in Fig. 1 (a) may be viewed from both back and front, but if used in this way one group of viewers sees a mirror image. Colored mica must not be used, and a filter is inserted between the back viewers and the tube to keep the color values correct and compensate for the light lost in the mica and fluorescent powder when the direction of viewing is reversed.

The tube shown in Fig. 2 can only be viewed from the front, but having one cathode-ray beam perpendicular to the screen simplified the setup of the apparatus. The tubes give a very bright picture due to the absence of color filters and the fact that special powders are used giving only the desired colors which are seen additively.

The tubes give excellent stereoscopic television images when used

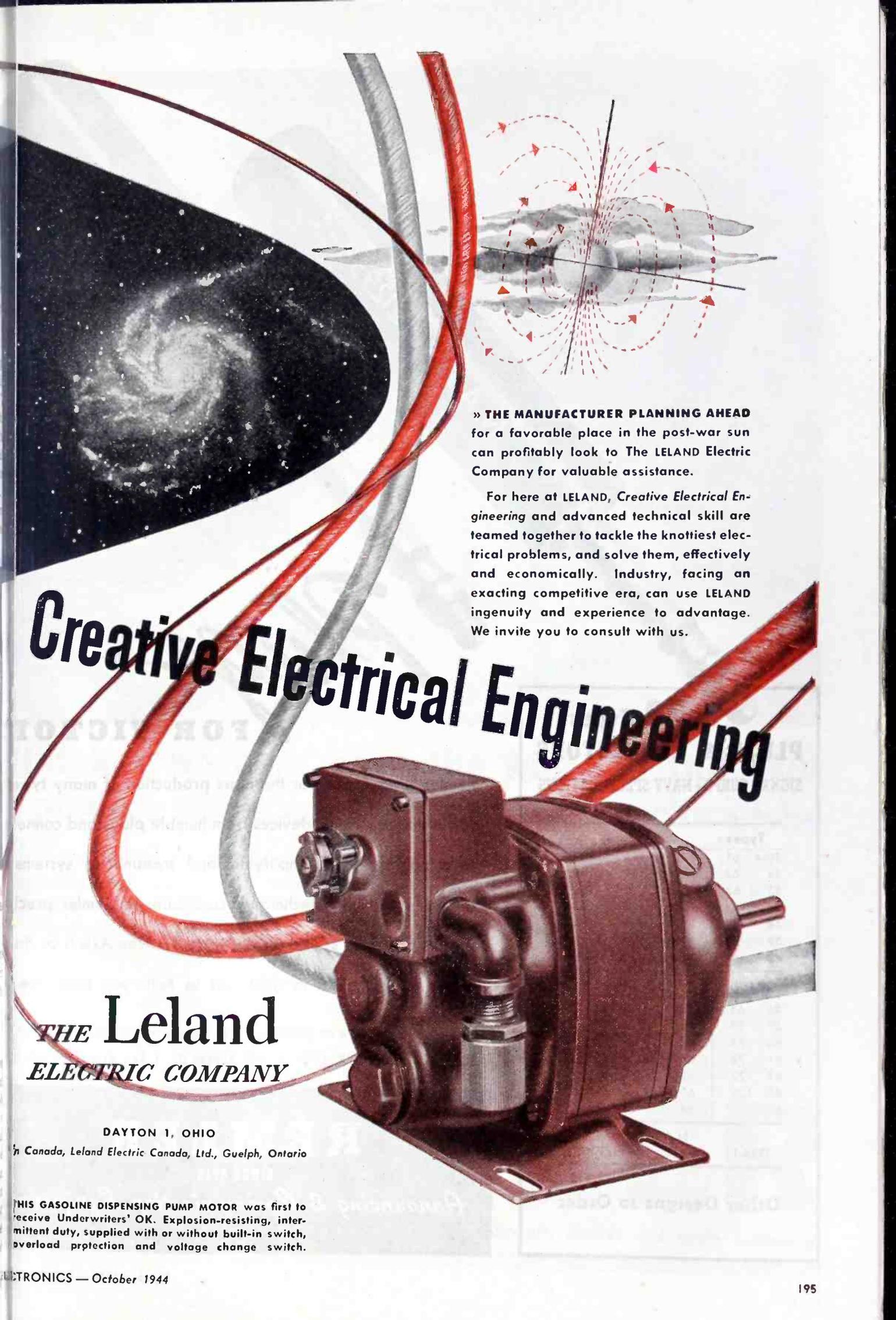


John L. Baird holds his new double-beam double-phosphor coating cathode-ray tube

with a stereoscopic transmitter. The blue-green and orange-red images form a stereoscopic pair when viewed through colored glasses.

New Form of Scanning

In the present form of scanning, all the lines in successive frames are of the same color, the color changing with each successive frame. In the new form of scanning now being developed, successive lines are of different color and the number of lines is made a non-multiple of the number of colors, so that every line of the complete color picture has successively



» **THE MANUFACTURER PLANNING AHEAD** for a favorable place in the post-war sun can profitably look to The LELAND Electric Company for valuable assistance.

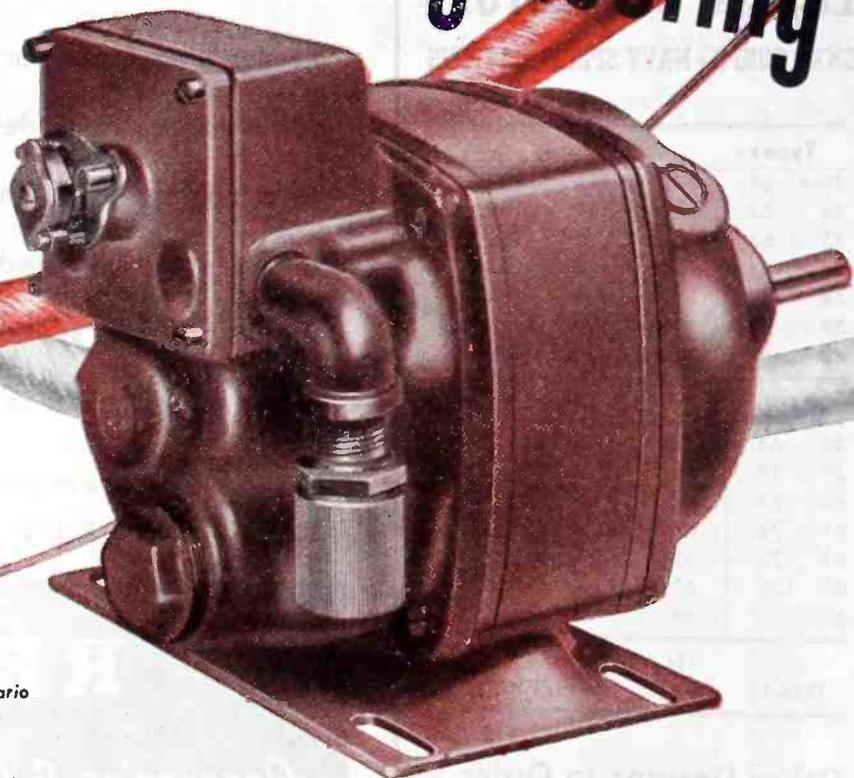
For here at LELAND, *Creative Electrical Engineering* and advanced technical skill are teamed together to tackle the knottiest electrical problems, and solve them, effectively and economically. Industry, facing an exacting competitive era, can use LELAND ingenuity and experience to advantage. We invite you to consult with us.

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THIS GASOLINE DISPENSING PUMP MOTOR was first to receive Underwriters' OK. Explosion-resisting, intermittent duty, supplied with or without built-in switch, overload protection and voltage change switch.



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Types:		PL		
50-A	61	74	114	150
54	62	76	119	159
55	63	77	120	160
56	64	104	124	291-A
58	65	108	125	354
59	67	109	127	
60	68	112	149	

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

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Remler is equipped for the mass production of many types of radio and electronic devices from humble plugs and connectors to complete sound amplifying and transmitting systems. Ingenious production techniques contribute to Remler precision, reduce costs and speed up deliveries. • The Axis is on the run and final Victory is in sight. Let us help you finish the job.

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Announcing & Communication Equipment



Whitaker workers have the will and the skill to produce wiring assemblies to your specifications

The girls who work in our plants are skilled technicians—and we can prove it. For example, the picture shown above illustrates one of the many complicated assemblies being turned out for war needs by our St. Joseph plants. The job looks difficult, and it would be except for the fact that we have a quarter of a century of experience.

Investigate and you will find that Whitaker has the "know how" and ample plant facilities to turn out cable assemblies, wiring harnesses, and flexible leads for power and lighting . . . Your inquiries are solicited. Whitaker Cable Corporation, 1307 Burlington Ave., Kansas City 16, Mo. . . St. Joseph, Mo. . . Philadelphia . . . Oakland.

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Cables, Wiring Harnesses and Assemblies for Automotive, Aircraft, Marine and Radio Equipment

Req. No. PURCHASE ORDER
 To Superior Graphite Products Company, Poughkeepsie, New York.
 Date January 3rd, 1920.
 Ship Via F. O. B. Poughkeepsie, N. Y.

Quantity	Description	Price
1,000,000	Motor Brushes - Your Grade No. 2 - As Per our B/P MF-17	\$46.00 Per M

- Shipping Specifications -
 Shipments to be made in accordance with schedule, which will be issued to you on the 1st of each month - 200,000 of the above quantity to be delivered to Willys Corporation, Poughkeepsie, New York - 800,000 of the above quantity to be delivered to Willys Corporation, Toledo, Ohio - Plant No. 2.

1. Acknowledgment form attached must be filled in and returned immediately. This order and its acceptance by you are subject to the following conditions:
2. All over-shipments are made on your responsibility; we reserve the right to reject and return, at your expense, material in excess of quantity ordered.
3. The right is reserved to cancel this order if not filled within time specified herein.
4. In consideration of the purchase of the above described articles, Seller agrees to defend, protect and save harmless the Willys Corporation, and its subsidiary or affiliated companies, its or their successors, assigns, customers, and the users of its or their product, against all suits, at law or in equity, and from damages, claims, demands and judgments for actual or alleged infringements of United States or foreign letters patent by reason of the sale or use of the articles hereby purchased.

THE ELECTRIC AUTO-LITE CO.



A quarter of a century ago Superior Carbon Products began operations in Poughkeepsie, N. Y. as the Superior Graphite Products Company. Our "first customer" was The Electric Auto-Lite Company of Toledo . . . It is a pleasure to be serving Auto-Lite still. We like to think that perhaps Superior Carbon Brushes have contributed something to the excellence of the Electric Auto-Lite product.

No, we're not going to deliver a lecture on the value of quality in keeping customers on one's list. Certainly we will exert every effort to maintain the quality of Superior Carbon Brushes . . . Nor on the importance of service and deliveries. However, we promise you our utmost in this respect despite the present difficult conditions with which we all have to contend. We will endeavor to make Superior service worthy of a place in every customer's picture.

SUPERIOR CARBON PRODUCTS, INC.
 9115 GEORGE AVENUE CLEVELAND 5, OHIO



shown each of the primary colors. The object of this is to reduce color flicker. Where frame by frame color alteration is used, flicker becomes prominent in any large area of a single color, for example, if the picture is showing a large blue area, this blue appears in the blue frame only. While the red and green frames are appearing, it is not shown, so that the frequency of the repetition is reduced and flicker accentuated. With line by line color alteration each color appears in every frame. This form of scanning does not lend itself to the revolving disc system.

Routing Cabs by Radio

A PLAN PROPOSED by Cab Research Bureau, Inc., representing the taxi industry, and the Electronic Department of General Electric Company would make it possible to establish contact by radio with any cab anywhere in Cleveland, reducing cruising mileage and eliminate unattended call boxes connected to telephone lines. If approval can be obtained from the FCC, this would be the first two-way taxicab radio system in the country.

The plan calls for one main transmitter for the downtown area and two others to cover the rest of the city. Each transmitter would have four channels, with 100 cabs assigned to each channel.

That radio-equipped cabs might be very useful in emergencies growing out of fire, crime, and accidents was pointed out by D. L. Chesnut, G-E commercial engineer. He pointed out that, "the taxicab industry in each major city might draw up an agreement with the city permitting the police department to commandeer its radio cabs and its headquarters station at any time that a major public disturbance should warrant."

Robot Radio Stations Forecast Weather

AUTOMATIC WEATHER stations secret locations from the arctic to the tropics are playing a major role in coordinating allied land, sea and air attacks with favorable weather. The robot weather bureaus were de-

Sgt. Spring, M.E., E.E., MET.E., CH.E., etc.



WE'VE GOT HIM COVERED

The Hunter Data Book has provided many ideas for spring-actuated devices that are doing their job to finish off the Axis. This handy packed book is full of information you need at your desk or drawing board. For a free copy, send your signature on your business letterhead. It will be mailed promptly.

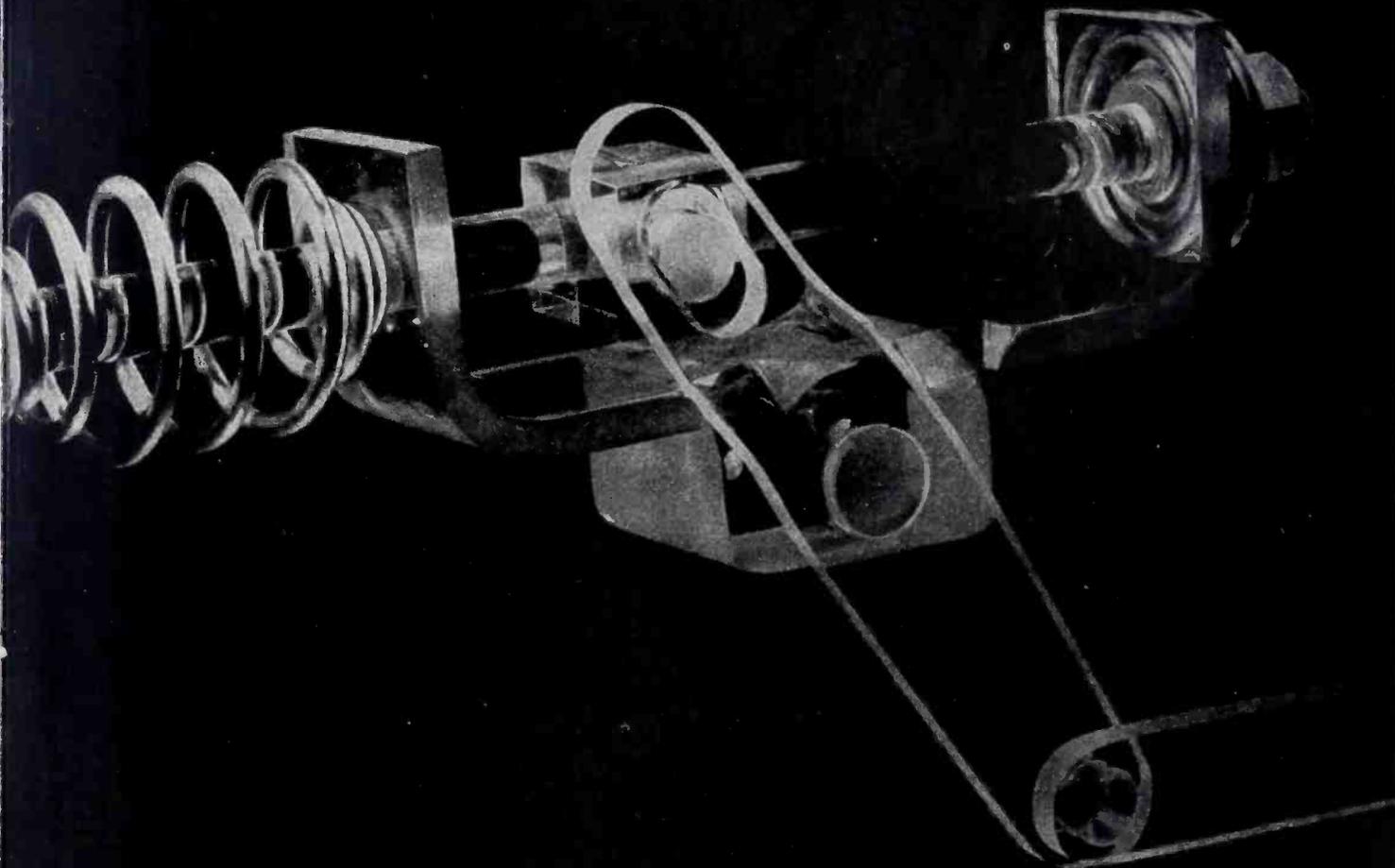
THERE was a time, very likely within your memory—when a spring was simply a curlicue of wire. You made it. If it didn't work, you gave it another twist and tried again. This cut-and-try approach was certainly not design—and hardly economical manufacture. But it had its day . . . and that day is over.

Now, to fit a spring precisely for the job it must do in your product . . . to make it an ambassador of the quality and per-

formance your customers expect from you, requires all the scientific knowledge a spring manufacturer can bring to bear.

The most naive-looking spring will often surrender only to the combined efforts of calculus, metallurgy and statistical control of quality. But in 99-44/100 percent of the problems, science wins out where rule-of-thumb would flop. The war has proved the case for scientific spring making. Future applications will rest on that proof.

THE BARREL SPRING—The barrel spring is a fundamental spring form, designed to resist, or store up until wanted, a compressive force, and to compact into the minimum solid height. One of many for-instance applications for barrel springs is shown in the Plexiglas model below.



WIRE-PLANNING NOW

will place your product in an advanced position

for POST-WAR competition



ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt.
The first lightweight, small diameter, flame-resistant hookup, designed in 1937 and widely used since in airborne and ground communication systems, electronic devices, instruments and apparatus. Operating temperatures range from 125° C. to minus 50° C. Also with tinned copper shielding braid and in twisted pair or triple construction.

ROCKBESTOS THERMOSTAT CONTROL WIRE

Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125", .025" or (for 115 volt service) .031" of felled asbestos insulation and steel armor.
A multi-conductor control wire for low voltage intercommunicating, signal and temperature control systems. Its life-time heatproof and fireproof insulation and rugged abrasion-resisting steel armor will give you trouble-proof circuits.

ROCKBESTOS 600 VOLT A.V.C. SWITCHBOARD WIRE

Sizes No. 18 to 4/0 AWG with varnished cambric and impregnated asbestos insulation and gray, black, white or colored flameproof cotton braid.
Combine fire insurance and fine appearance in your switchboards with Rockbestos A.V.C. Switchboard Wire. It is fireproof, will not dry out under heat, sharp clean bends can be made without cracking the braid as the asbestos firewall acts as a cushion. Rockbestos A.V.C. Hinge Cable and Switchboard Bus Cable have the same characteristics.

ROCKBESTOS TYPE CA LEAD WIRE

Has high dielectric strength and moisture resistance for use where heat and humidity are encountered. No. 20 to 8 AWG solid or stranded copper, monel or nickel conductors insulated with synthetic tape and various thicknesses of felled asbestos finished in black, white or colors for coding purposes. Also with All-Asbestos insulation only, where high moisture resistance is not required.

INVESTIGATE ROCKBESTOS PERMANENTLY INSULATED WIRES, CABLES AND CORDS

Promptness in getting products on the market will reward peacetime producers. But *staying* in the market is what pays long-term dividends. You can secure an advanced position and earn consumer goodwill for your products by eliminating potential wire-failures through careful wire-planning in the design stages.

The experience of many designers and manufacturers proves that by giving advance consideration to such factors as operating temperatures and voltages, dielectric strength, diameters, vibration, flexing, ambient temperatures, Underwriters' approval, etc., possible wire-failures can be eliminated before the product reaches the user.

In wire-planning your product, be sure to investigate Rockbestos wires, cables and cords. They all have a *permanent asbestos insulation* that resists heat, flame, cold, moisture, oil, grease and alkalis. One of the 122 standard constructions will probably meet your requirements. If, however, you have a peculiar operating condition or some other special wire requirement, Rockbestos Research will gladly develop a special construction to meet your particular needs.

For engineering assistance on the complete solution of your wire problems, write the nearest branch office or:

Rockbestos Products Corporation, 416 Nicoll St.
New Haven 4, Conn.

FOR VICTORY... BUY WAR BONDS

ROCKBESTOS RESEARCH

Solves Difficult Wiring Problems





Yesterday and **TODAY**

The Army-Navy Production Award for outstanding achievement in producing vitally important materials essential to the war effort will be an added incentive to the management and employees of

WARD PRODUCTS CORPORATION to keep producing more and better equipment for the men who are doing the fighting. While yesterday WARD Antennas were accessories for pleasure, today they are implements of War.



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veloped and placed in production by Friez Instrument Div. of Bendix Aviation Corp. within a year after the Navy requested the devices.

The Navy wanted a device which would report automatically on weather conditions by radio from remote points back to official weather control locations, and while Friez engineers already had the necessary meteorological instruments they had to start more or less from scratch on equipment for power and timing of automatic radio devices necessary to broadcast reports and data continuously gathered by recording instruments. Weather and termite-proof insulated houses were developed to shelter the recording and radio instruments. Since weather in the English Channel originates around Greenland, it was necessary to build the automatic stations able to withstand the severe arctic climate of that region. For the most part, the stations require servicing only at intervals of several months.

• • •

Electronic Operation of a Standard Stop-Watch

By R. J. WBY AND J. H. JUPE
Middlesex, England

IN USING A STOP-WATCH over intervals of one minute or less the error due to human causes, may be appreciable and the following description deals with apparatus designed to overcome this. A phototube is used so that the mechanism being timed is physically separate from the timing apparatus, with the result that mutual interference is nil.

The light beam can be interrupted or modulated in various ways but to reduce circuit errors to a minimum the best method is to operate the relay in the same direction at both ends of the cycle. The inherent time delays will then cancel out. This device has been in use for a long time and has been found to be extremely reliable and convenient for laboratory work.

Four basic modes of operation are possible, as follows:

1. Double occultation;
2. Double illumination;
3. Single occultation;
4. Single illumination.

A schematic of the circuit for the

Speak no . . . See no . . . Hear no . . .

Do no



post war reconversion

No wonder American industrialists are dizzy! — Columnists, commentators, conferences and a host of critics on the sidelines advising business to "Go ahead" — to "Hold back" — to "Stand still."

Red lights today, green lights tomorrow.

Through the maze of conflicting regulations, press releases, industry bulletins, it is safe to predict, however, that civilian production will resume shortly. But we must win the war first.

We at G. I., realizing that wars always end more suddenly than they begin, decided long ago on a post war planning schedule. It may help

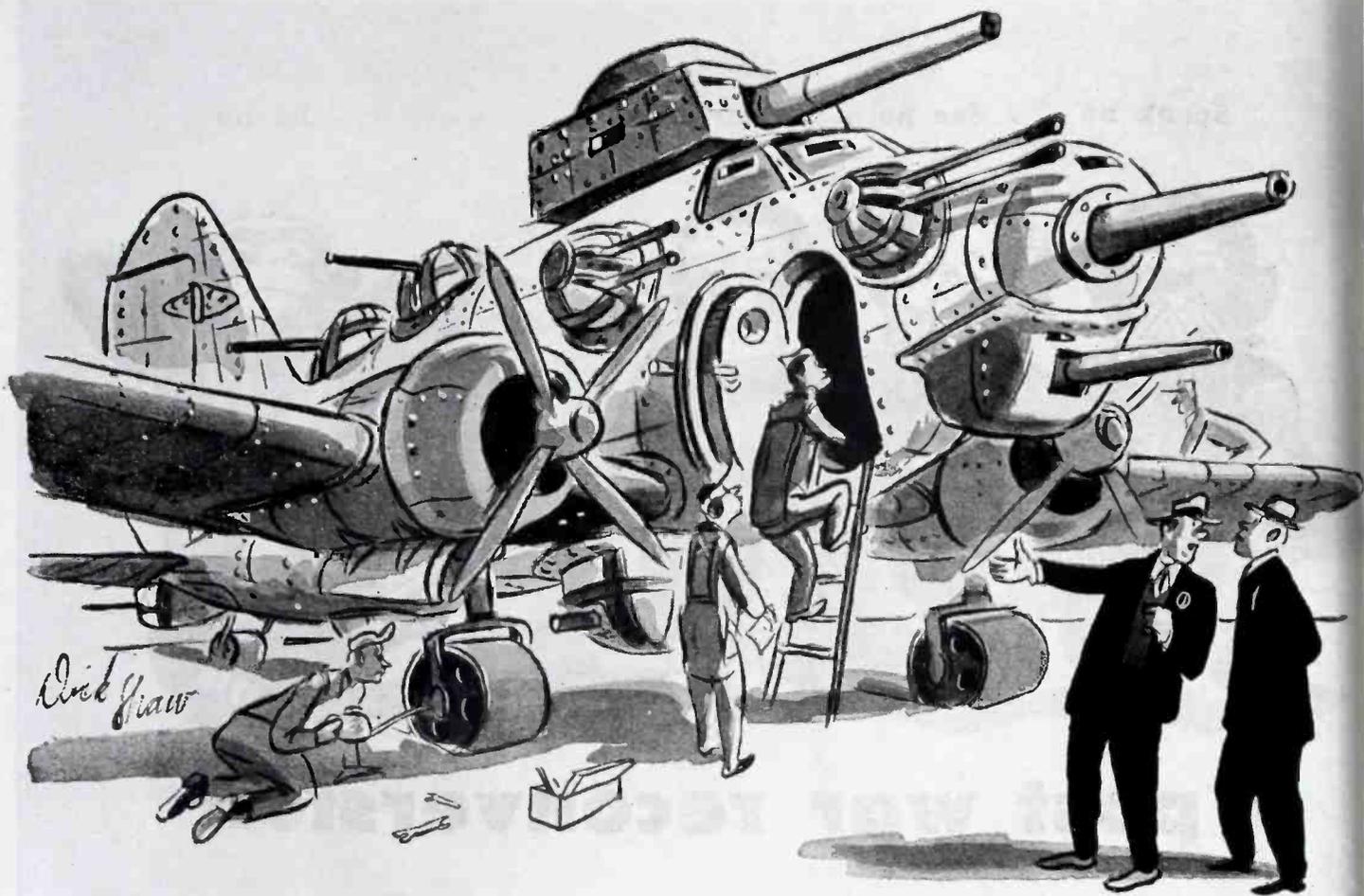


to clarify your problem to know that we will be under way immediately when Uncle Sam issues the go-ahead signal.

Our products comprise new and improved components in the electronic and radio fields — variable condensers, automatic tuning mechanisms, record changers and new items developed and perfected from the research of our wartime experience.

**GENERAL INSTRUMENT
CORP.**

829 NEWARK AVE., ELIZABETH 3, N. J.



"We saved enough weight by using Cannon Plugs to add a little more armament"

CANNON PLUGS ARE DEFINITELY ON THE LIGHT SIDE . . .

Sure Cannon Plugs do weigh a little something—but the least possible. They're engineered that way.

First off they're *designed* for aircraft use—not just adapted to it. They're strong where strength is needed. Excess weight is saved by cutting out factors that don't contribute to structural soundness.

Then, too, Cannon Plugs are precision built which means more than just the close fit of all parts. With Cannon, precision also means burring and cleaning, trimming down and finishing off all excess material.

Shells are die-cast of alloys that are tough but light. Pins and sockets machined to closest tolerances to save weight. Inserts, rings, springs, clips and clamps—each part designed to do its job exactly without waste.

The weight saved with one Cannon Plug makes little difference. But with Cannon Plugs on all the circuits a great deal is saved—actually several pounds per plane.

Speaking of weight saving, just look over the lightweight connectors in the Cannon Type AN series, built strictly to Army-Navy Specifications. A new 4th Edition Type AN Bulletin is ready for distribution. It's free for the asking. Write Dept. A-120, Cannon Electric Development Co., Los Angeles 31, Calif.

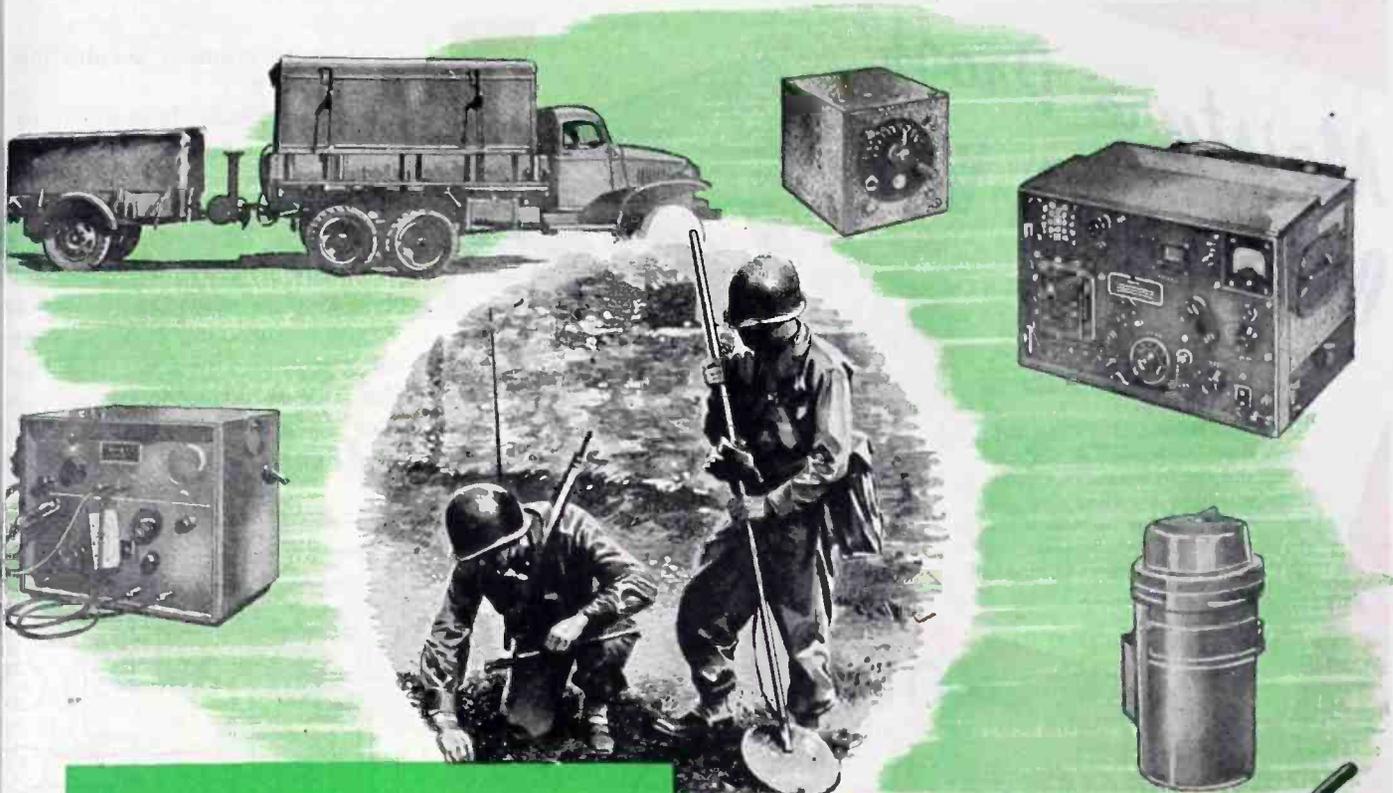
CANNON ELECTRIC

Cannon Electric Development Co., Los Angeles 31, Calif.

Canadian Factory and Engineering Office:
Cannon Electric Company, Limited, Toronto

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182,826
Man Hours of
RESEARCH

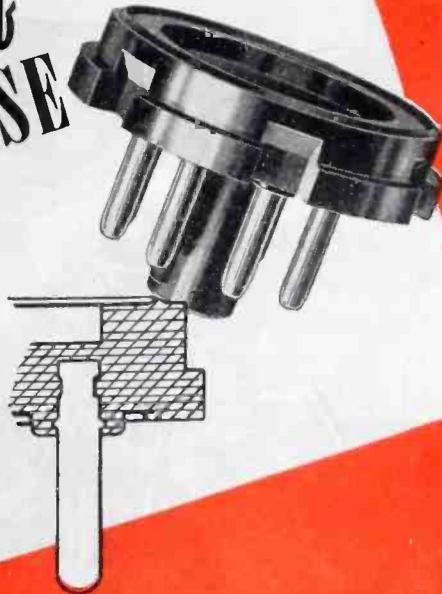
Since Pearl Harbor, International Detrola research engineers have logged this amazing total in their successful efforts to develop and improve Mine Detectors, Aircraft Radio Transmitters, and Receivers, and many other important military electronic devices. The company's other engineering groups also have made great contribution to the quality and volume of electronic weapons streaming from its efficient Detroit assembly lines to the many battlefronts of Victory. The same engineering inventiveness and trained imagination will be an inseparable quality of Detrola-built Radio Receivers, Television Receivers, Automatic Record Changers, and other electronic instruments.

DETROLA RADIO
 DIVISION OF INTERNATIONAL DETROLA CORPORATION • BEARD AT CHATFIELD, DETROIT 8, MICH.
 C. RUSSELL FELDMANN **dr** PRESIDENT

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Moisture Proof OCTAL-TYPE BASE

Despite contraction and expansion caused by heat and cold, HOWARD'S Octal Type Base "seals out" all moisture and dirt by means of a gasket seated on a sealing ring. Designed for use in radio tubes, electrolytic condensers, and practically all types of plug-in equipment.



MOLDED-IN PINS

Because HOWARD Molds-in the pins there is a complete seal around the pins preventing the entrance of any moisture or dirt. HOWARD Octal type base is made in black or natural Bakelite. Write HOWARD today for prices.

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HOWARD MANUFACTURING CORP.

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Latest Permanent Magnet MANUAL

NEW! A valuable, up-to-the-minute manual on the design, production and application of the modern permanent magnet. Prepared by The Arnold Engineering Company, this is an authoritative treatise based on many years' experience in the

production of Alnico permanent magnets for a wide range of applications.

Contents include such subjects as Magnet Materials, Resistance Comparisons, Physical and Magnetic Properties, Demagnetization and Energy Curves, Fabrication, Design and Testing. Charts and tables illustrate and explain various aspects of the discussion.

Recent improvements have opened many new fields for permanent magnets to reduce the cost and improve the efficiency of many devices.

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THE ARNOLD ENGINEERING COMPANY

147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Specialists in the Manufacture of ALNICO PERMANENT MAGNETS

most useful (double occultation) is given in Fig. 1.

The phototube is coupled to the grid of the amplifier tube by resistor R_1 and capacitor C_1 , while in the anode circuit is an ordinary telephone-type relay. Double-pole double-throw contacts are provided on this and its operation is indicated by the signal lamp L , being supplied via contacts 5 and 6. Grid bias of the tube is adjusted by potentiometer R_2 until sufficient anode current flows to give positive operation

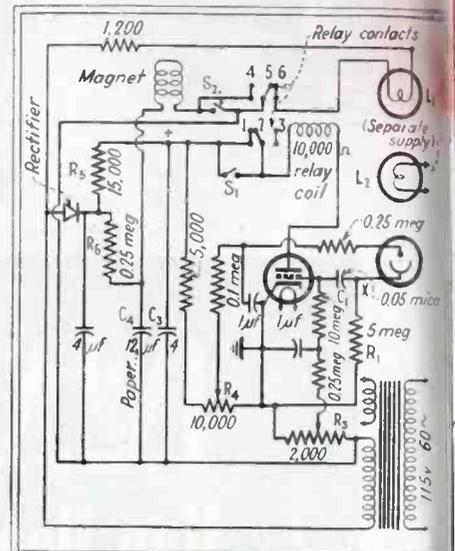


Fig. 1—Circuit for starting and stopping a stop-watch by two interruptions of a lightbeam. Lamp L_1 is a 230-volt, 15-watt bulb

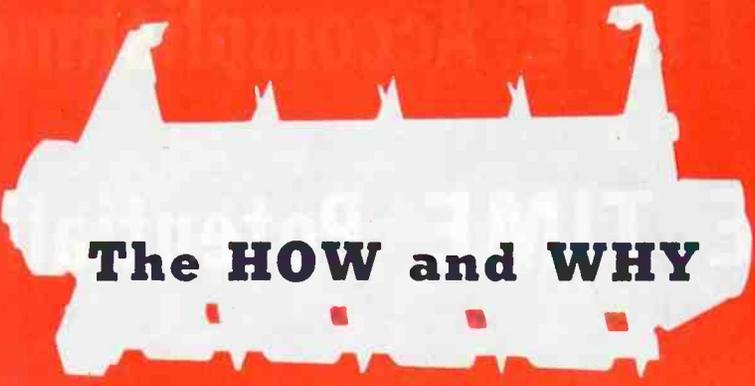
of the relay (approximately 3.5 to 4 ma.). The phototube anode potential is adjusted by means of resistance R_2 , both anode supplies being obtained from the metal rectifier and smoothed by capacitor C_1 in conjunction with resistor R_1 .

Operation

Normally, the phototube is illuminated, so that point X is positive with respect to the cathode of the amplifier tube. Interruption of the beam causes the grid potential to fall to a low value and the relay releases when the anode current changes. Three things then happen:

The watch is started by the electromagnet being energized; the signal lamp is no longer illuminated; the anode circuit of the amplifier tube is opened.

This last is useful as the amplifier is rendered proof against control by the phototube while timing is in progress. Near the end of the timed



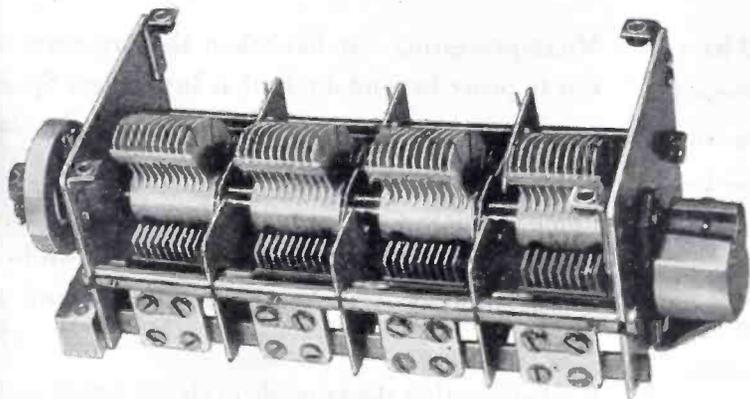
The HOW and WHY

of variable air condensers . . .

Here's HOW to get them. Variable air condensers of Radio Condenser Company will be available just as soon as the armed forces' demands end.

WHY use them? Because they provide such accurate and distinct tuning. You can't afford to overlook the fact they are being used today in radio apparatus of our armed

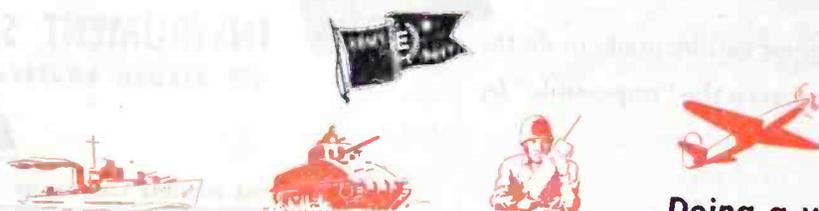
forces and provide such accurate tuning that these men—your post-war prospects — will want the same type reception in commercial sets. Give it to them by using our variable air condensers.



RADIO CONDENSER CO.

CAMDEN, N. J.

RADIO CONDENSER CO. LTD., TORONTO, CAN.



. . . Doing a war job today

some WAR TIME Accomplishments and PEACE TIME Potentialities of Beryllium Copper . . .

an Invitation

At the Metal Congress in Cleveland you will have the opportunity to see and to handle Micro-processed parts fabricated from beryllium copper wire and strip which heretofore have been impossible or impractical to produce in any metal; you will be able to examine specific examples of accomplishments in beryllium copper which represent attractive cost savings that can be applied to every-day peace-time products; you will be able to discuss at length with competent I-S engineers, the application of Micro-processing to your products of tomorrow.

Beryllium Copper can be made to do the exceptional and even the "impossible" by

Booth C-325
Oct. 16 to 20 inc.

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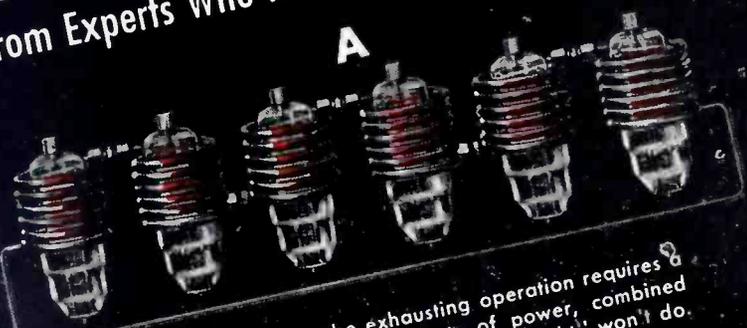
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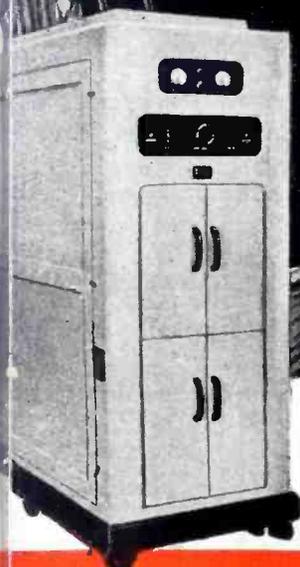
B
while this rapid surface hardening operation requires an entirely different amount of power, together with a different, predetermined frequency.



C
This job of heating the glue between layers of plywood requires still another totally different combination of power and frequency. Unlike A and B this is not induction but dielectric heating—in which the heat is generated within non-metallic substances.

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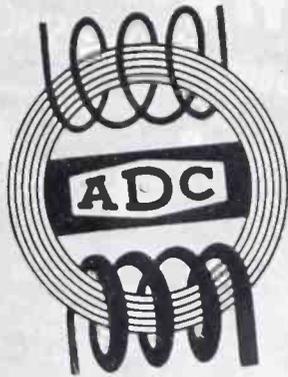
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cycle, pushbutton S_1 must be operated to reconnect the amplifier by allowing anode current to pass and pull in the relay armature. After this, the first occultation will energize the magnet and stop the watch. Switch S_1 resets the watch to zero.

Referring to the schematic, it will be seen that the current for operating the magnet is obtained from capacitor C_1 , which is charged to some 300 volts through resistor R_1 and discharged through the magnet coils when contact 5 closes on 4. Although the magnet requires some 50 ma. for its operation, the rectifier load is only increased by about 1.5 ma., and as the discharge is comparatively heavy and of short duration, the operation of the device is quick and positive.

Sometimes it is neither desirable nor possible to achieve double occultation of the phototube, in which case a flash of light from a moving mirror may be used to start and stop the watch. The circuit must then be revised as follows: 1. Interchange the positions of the phototube and the resistance R_1 ; 2. Vary the amplifier tube bias so that the anode current is normally zero and change over the connections to 5 and 6 of the relay. Contacts 1, 2, and 3, also reset button S_1 , will be cut out of the circuit.

Single Illumination or Occultation

When operation by single illumination or occultation is required

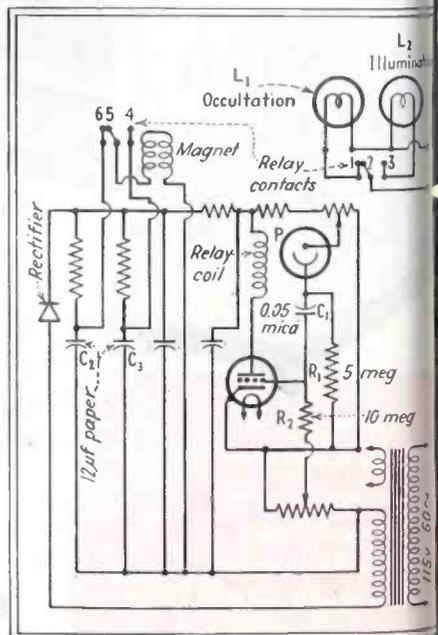


Fig. 2—Single illumination or occultation will operate the circuit above. Except as shown, constants of components are the same as Fig. 1

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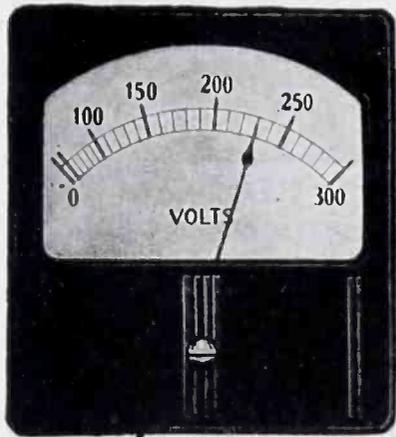
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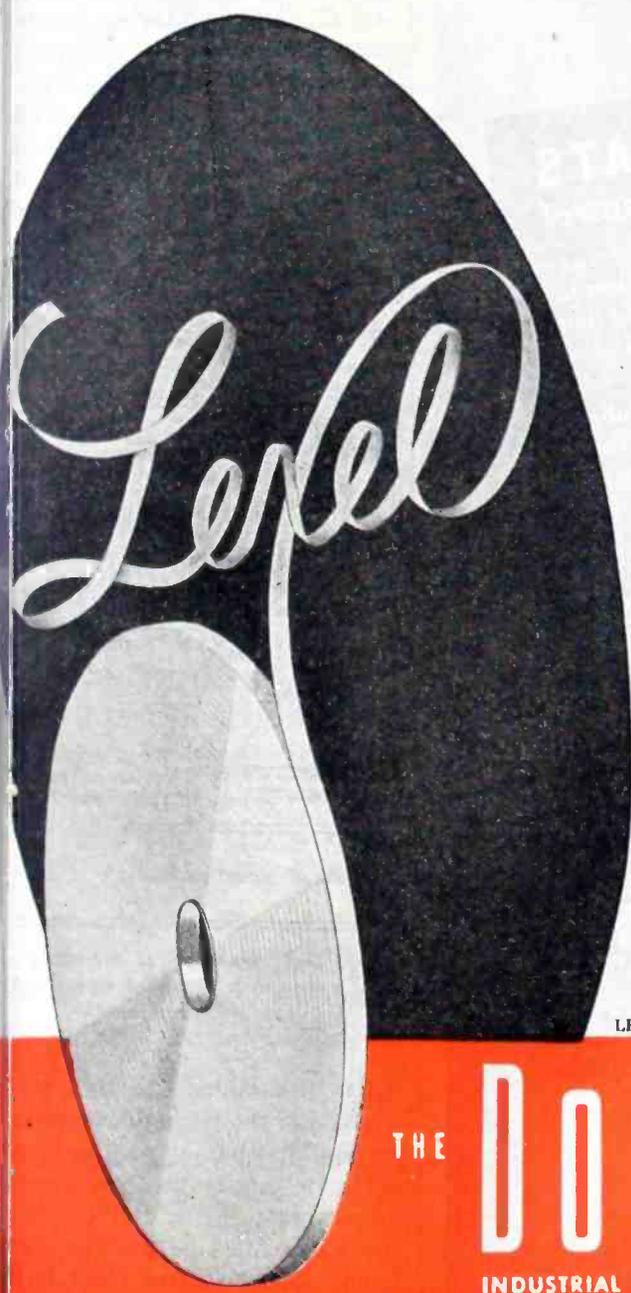
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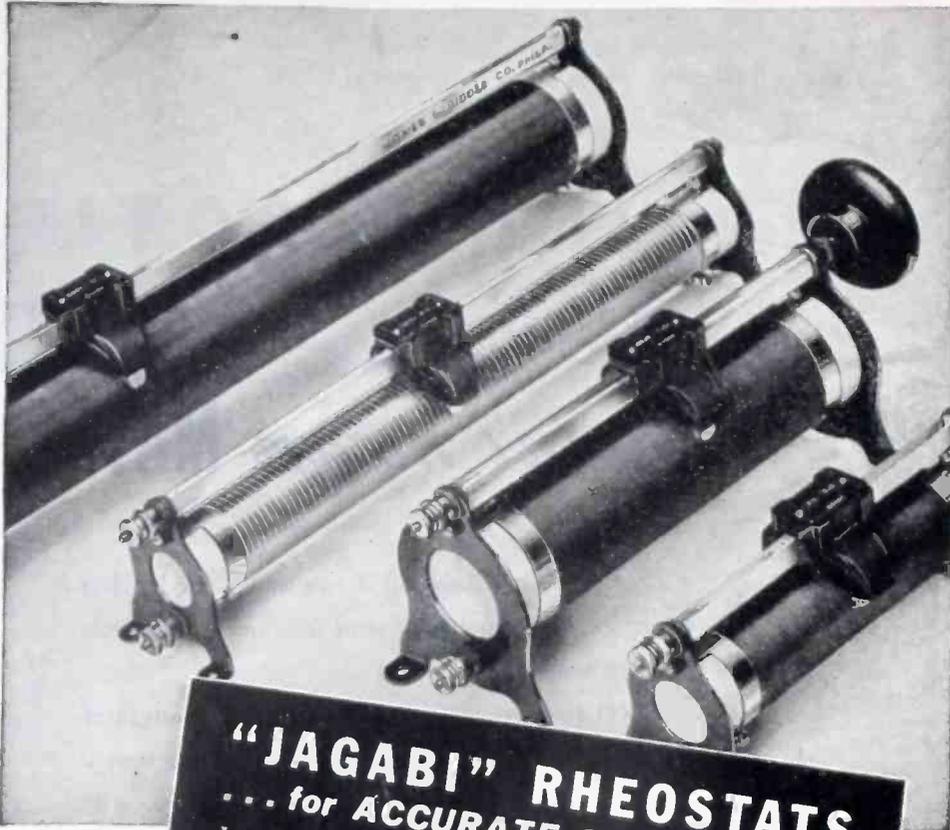
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"JAGABI" COMPRESSION CARBON RHEOSTATS

the simplified circuit shown in Fig. 2 may be used, in which case the bias of the tube is adjusted so that its normal anode current corresponds to the mean operating current of the relay.

Upon occultation, the relay will drop out, causing C_2 in Fig. 2 to discharge through the magnet winding and so start the watch. While the phototube is in darkness, the anode current will slowly rise (the time being determined by the time constant of R_1, R_2, C_1) but will not operate the relay owing to the pull-up current being different from the drop-out value.

When the phototube is illuminated at the end of the cycle, the anode current will rise still further and the relay will operate and energize the electromagnet from capacitor C_2 . A little later the anode current will return to its original value but the relay will still hold in. The circuit is then ready to respond to further occultation of the beam.

Modes of operation 3 or 4 are made possible by checking that the relay is in the correct condition before the timing cycle commences.

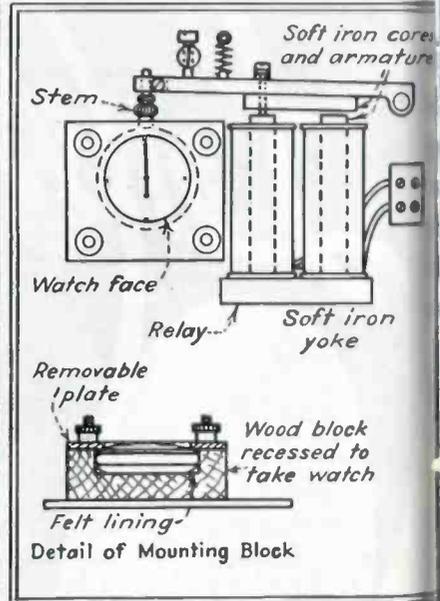
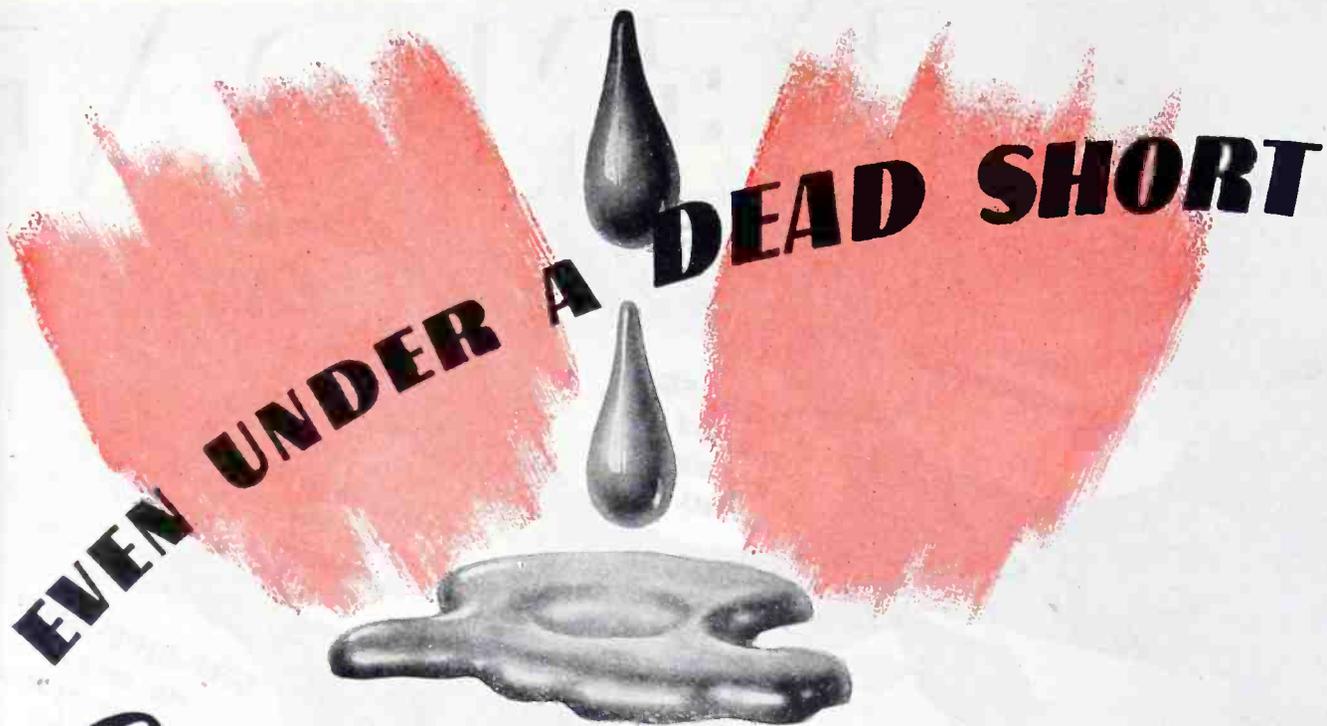


Fig. 3—Construction of mounting unit for adapting a standard stop-watch to an electronic starter

The signal lamps L_1 and L_2 may be marked to show whether occultation or illumination is required to operate the apparatus. As there are two capacitors, C_1 and C_2 , in use, the watch must be reset to zero by hand, otherwise two reset buttons are necessary.

The general arrangement of the



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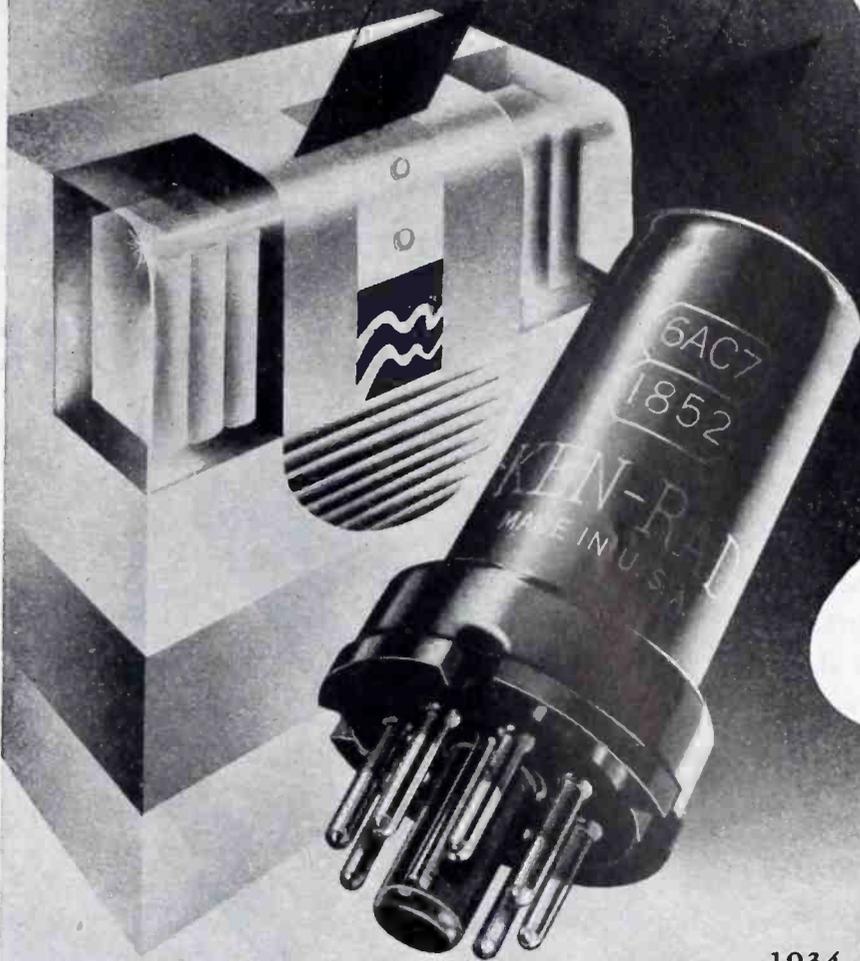
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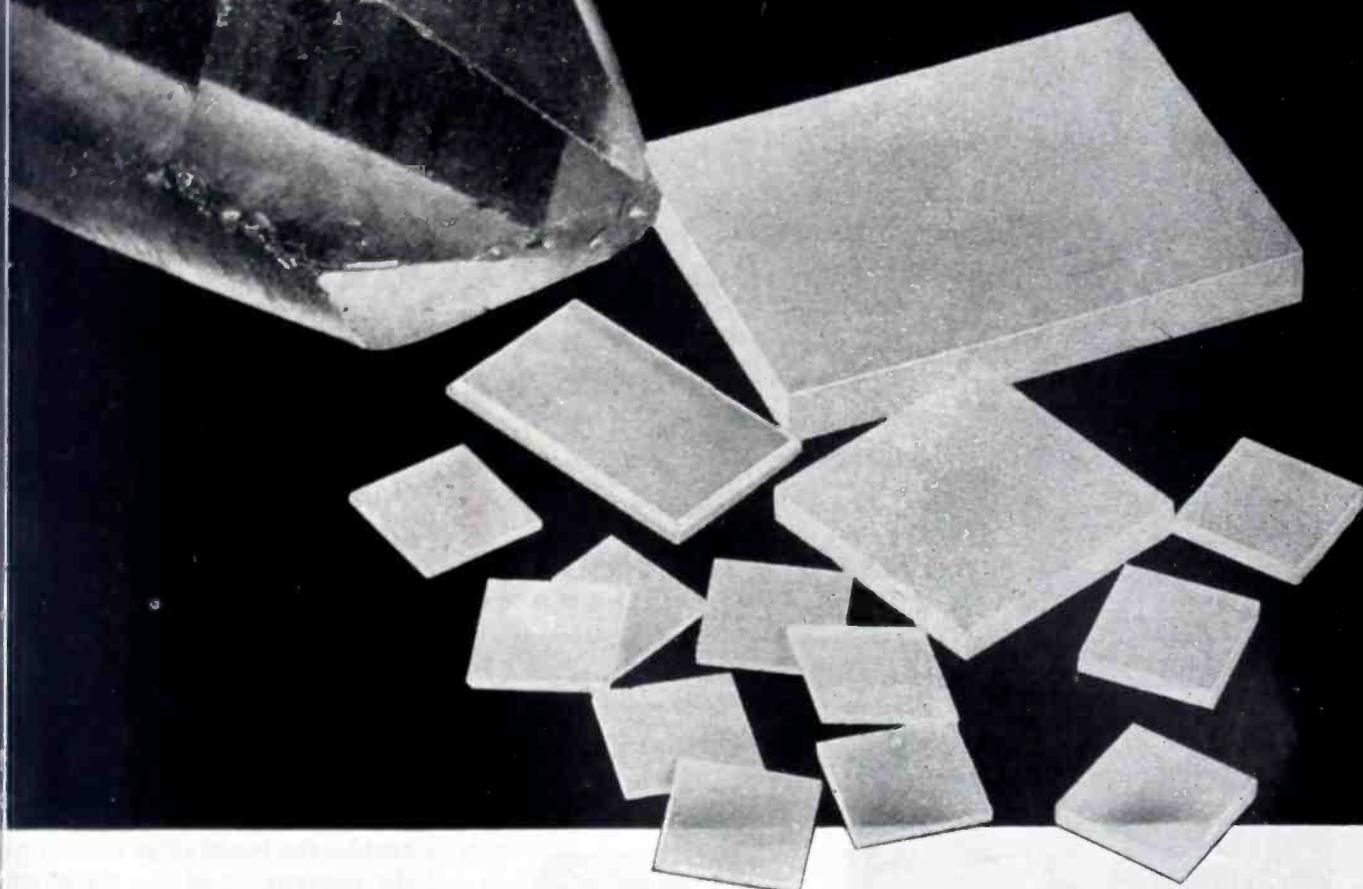
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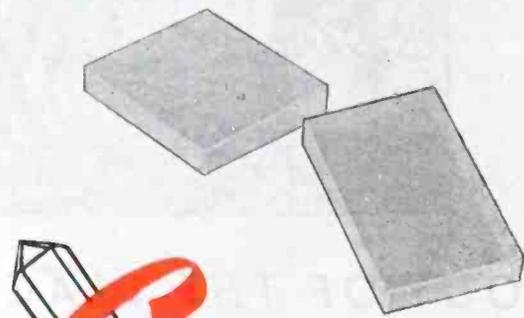
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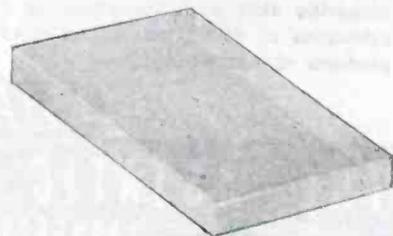
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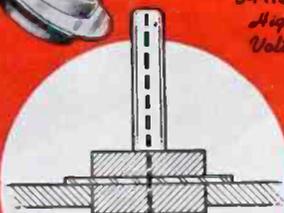
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watch unit is given in Fig. 3. Clamping nuts hold the watch in position and a felt pad prevents damage.

The electro-magnet coils are $3\frac{1}{4}$ in. long by $1\frac{1}{2}$ in. in diameter and are wound with No. 36 B and S enamelled copper wire, about 12,000 turns being necessary. A diameter of $\frac{3}{8}$ in. is adequate for the cores while a minimum air gap of 0.02 in. is satisfactory between armature and pole face.

It should be noted that the screw which projects through the armature to the pole face must touch the latter before the knob of the watch is fully depressed, otherwise considerable force may be exerted on the watch mechanism. Thanks are due the Editor of *Electronic Engineering* for permission to reproduce certain copyright material.

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Substitute for Car Antenna Checks Capacitance

By PAUL F. MAGEE

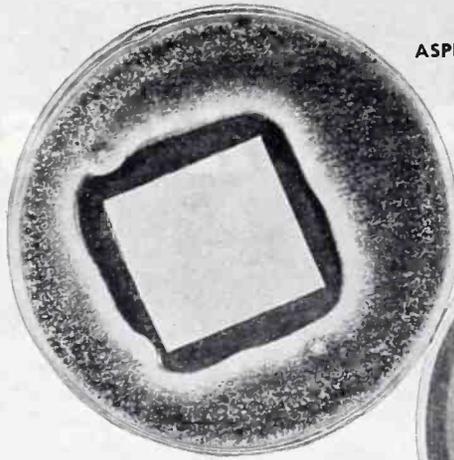
Cross Roads Auto Service, Berlin, Md.

DUE TO THE SHORTAGE of manpower, we have not been able to actually remove or reinstall any car radios, nor make any adjustments on the set in the car. However, we have been repairing them to a great extent on the bench after determining the capacitance of the car antenna with a simply-made capacitance bridge. This instrument enables the serviceman to line up the radio at the test bench under the same conditions as the set encounters when installed in the car.

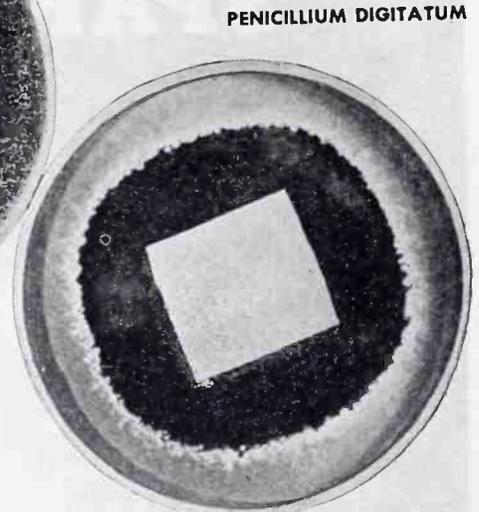
A reading is obtained by connecting the bridge unit to the car antenna with the antenna lead disconnected from the car radio set. The unit is then carried in to the service bench and plugged into the auto radio for the alignment procedure and a switch is set to connect the proper capacitance into the receiver input circuit. The time required to take the bridge reading is practically nil and by recording this reading the set can be aligned properly without the car antenna at some later date.

As illustrated in the diagram, the device is a bridge circuit using two resistors on one side of the bridge and two capacitors on the other side. One of these is a known

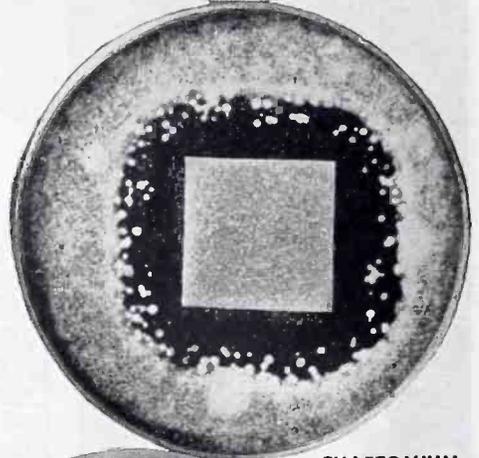
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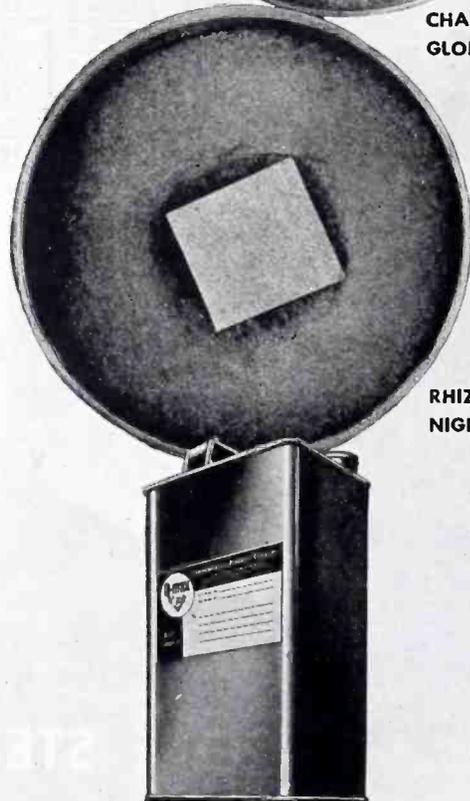
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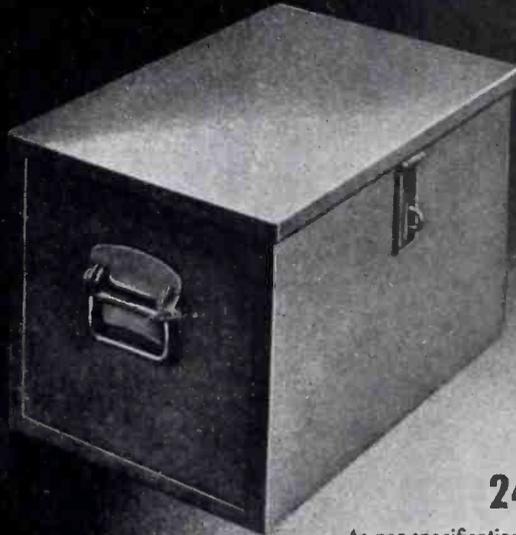
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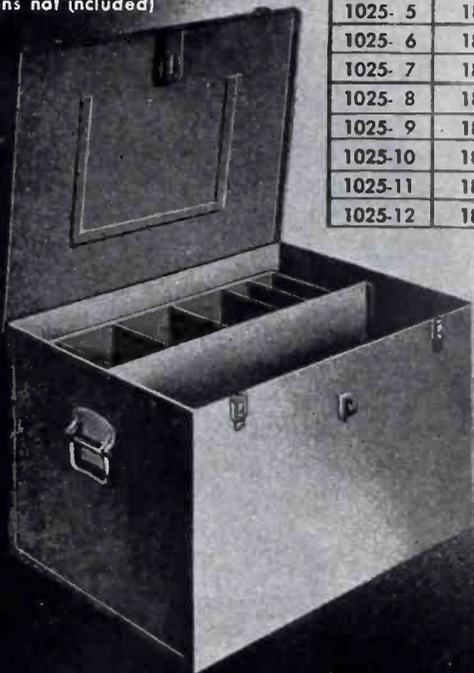
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1025- 6	18	9	9	1025-19	24	18	18
1025- 7	18	12	9	1025-20	24	12	9
1025- 8	18	6	6	1025-23	30	15	9
1025- 9	18	15	9	1025-14	30	15	12
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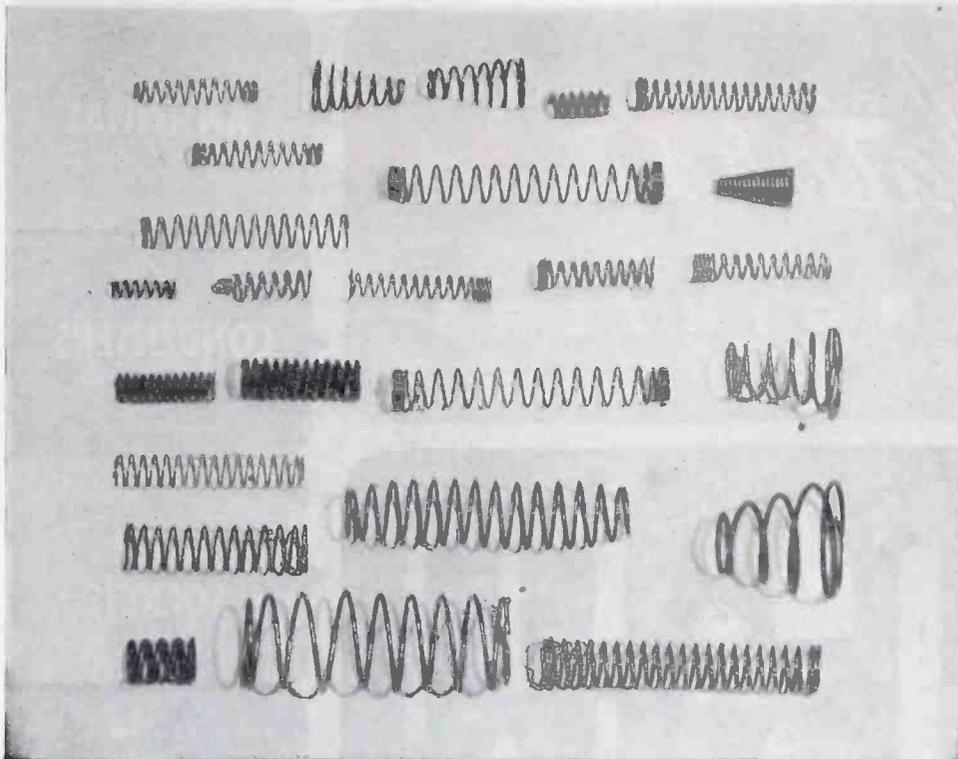


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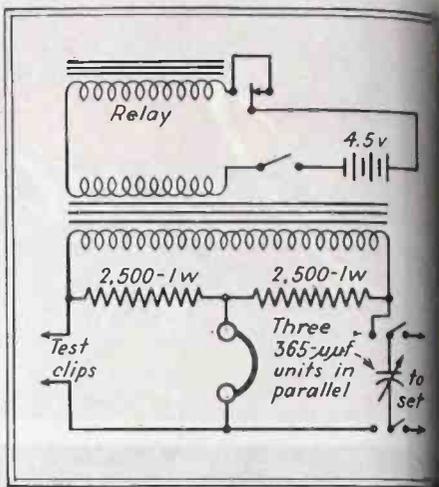
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capacitance and the other unknown. When connected as shown, the relay furnishes the buzzing sound to provide an audible sound for balancing the known capacitance to the unknown capacitance of the antenna circuit in the car.

The transformer is a line-to-voice-coil type. The voice-coil winding is connected in series with the relay, battery and switch.

Three flashlight batteries have lasted for a long time. The layout of the components is not critical and all of the parts were installed in a box 6 x 9 x 4 in. The dial is mounted on one end and was calibrated with the aid of a capacitance meter used in normal service work.

The device has sufficient antenna effect to permit operation of the set

Dial Reading	Cap. in $\mu\mu\text{f}$
0	100
20	160
40	300
60	550
80	900
100	1250

without an additional antenna connected if the set is operating properly. By using the unit on every set, a sense of judgment can be obtained as to whether the repaired set is satisfactory. The set is aligned for greatest sensitivity from one end of the band to the other, even if the oscillator trimmer capacitor has to be varied slightly to obtain satisfactory results.

A tuning gang having three 365- $\mu\mu\text{f}$ sections connected in parallel has sufficient capacitance to cover

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TECHNIQUE

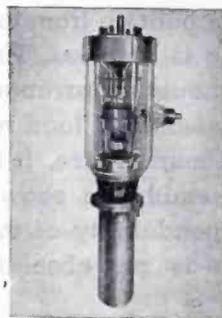
These metals are of increasing importance in radio transmitting tubes, and the simple operation above is proof of Machlett's ability to handle them. Here beryllium is being rolled into sheets from 0.004 to 0.020 inch thick, sheets that are vacuum-tight, and have adequate ductility at high temperatures.

Formerly it was believed to be impossible to make beryllium malleable, but Machlett decided to produce it in this form, because it then could be used as a part of the envelope in an X-ray tube. This would result in new tubes of superior utility in certain important applications, particularly X-ray diffraction, one vital use of which is in determining the axes of quartz crystals for radio frequency control; also there are

manifold uses in metallography.

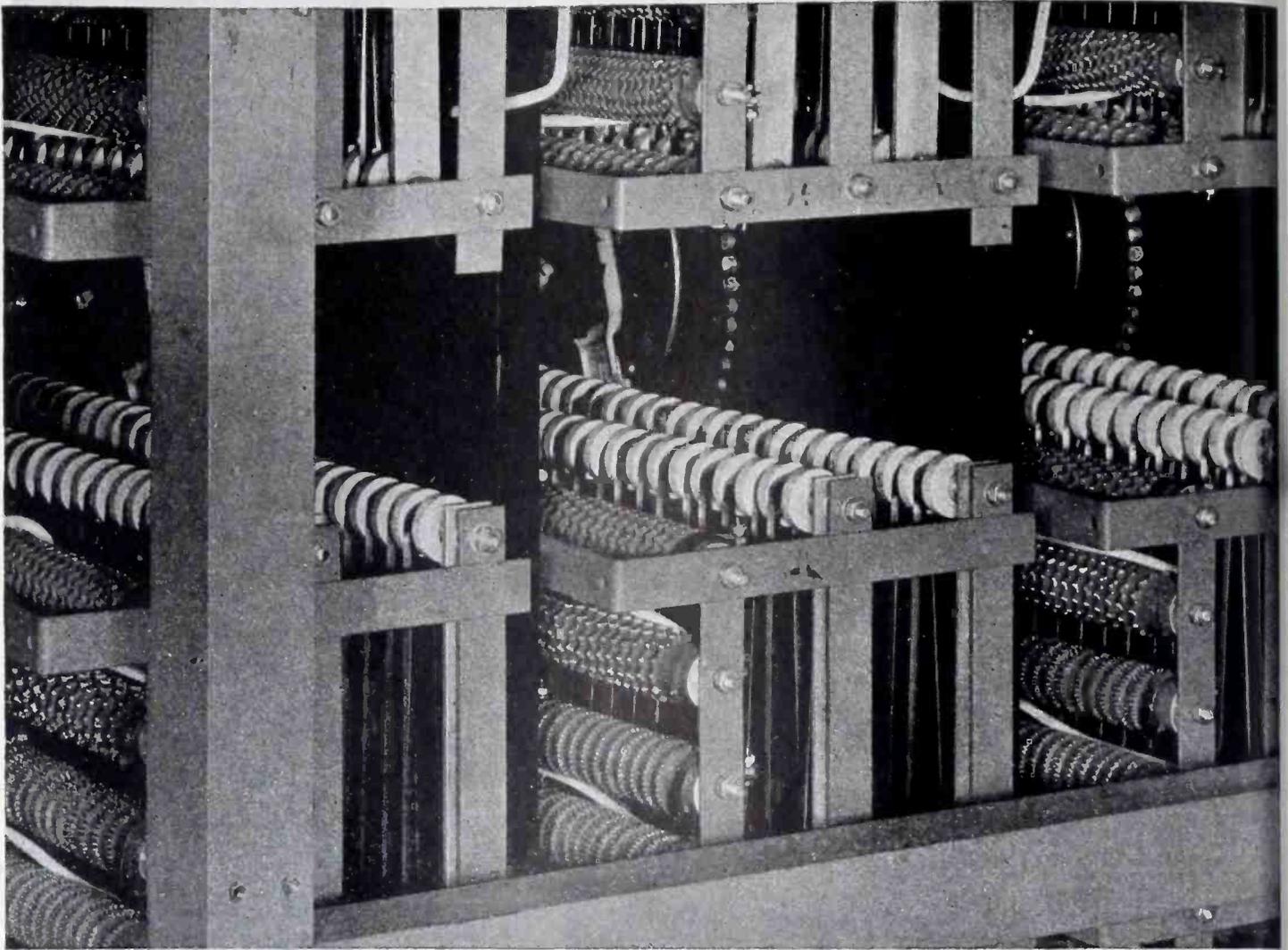
So Machlett did the impossible — beryllium was made malleable. Details are given in a scientific paper, copies of which are available.

Such an achievement is typical of the Machlett determination to overcome obstacles to the production of the most effective and desirable types of vacuum tubes, whether they be r-f oscillators for communications or induction heating, or X-ray tubes for industrial, scientific, medical or dental uses. The type of skill that produces "impossible" malleable beryllium is reflected in the construction of the Machlett ML-893 illustrated here . . . Machlett Laboratories, Inc., Springdale, Connecticut.



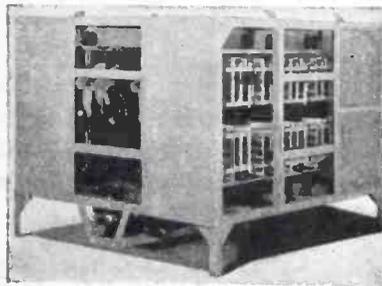
ML-893—high power oscillator and amplifier tube for radio and industrial purposes.

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X
RAY TUBES SINCE 1898
TODAY THEIR LARGEST MAKER



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ADAPTABILITY and dependability of resistors assume primary importance in the assembly of large rheostat control units. The wide range of resistance values and capacities that can be built up from the Ward Leonard line is limitless. The many types and mounting arrangements permit the meeting of load requirements in minimum space. It is obvious in an assembly as shown above that the dependability of the individual resistor is an absolute essential.



This motor operated Ward Leonard assembled rheostat is built up from several types of Ward Leonard Resistors.

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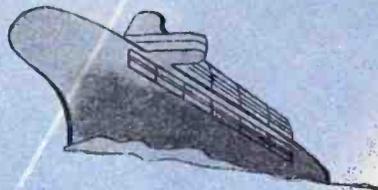
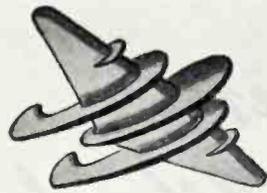
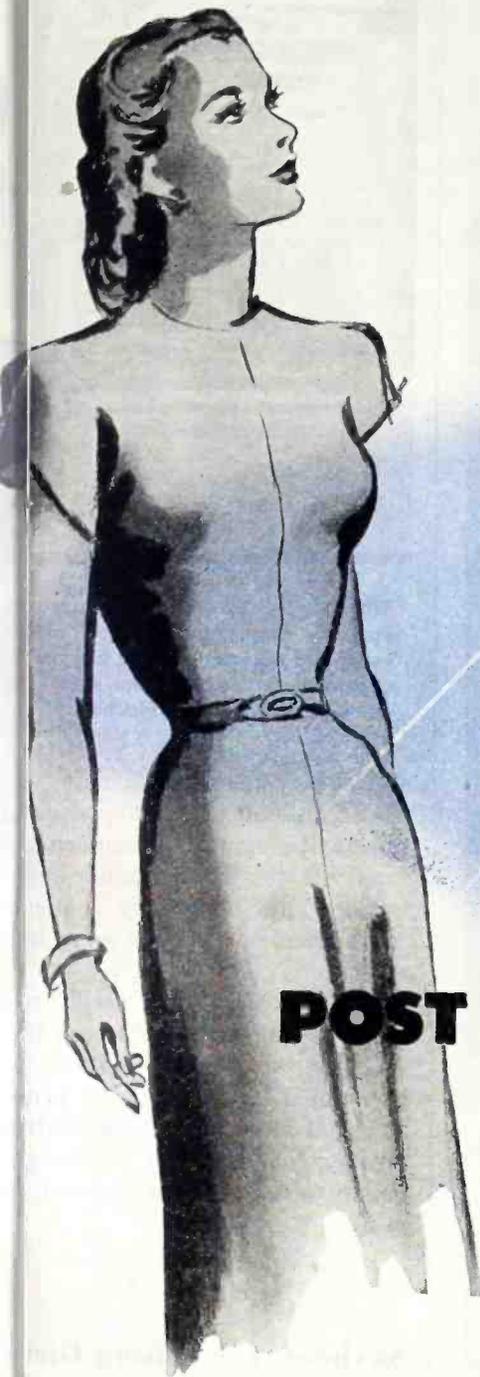
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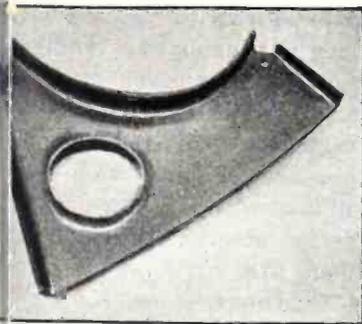
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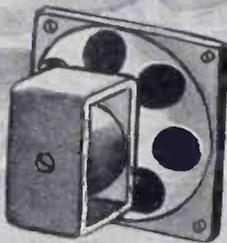
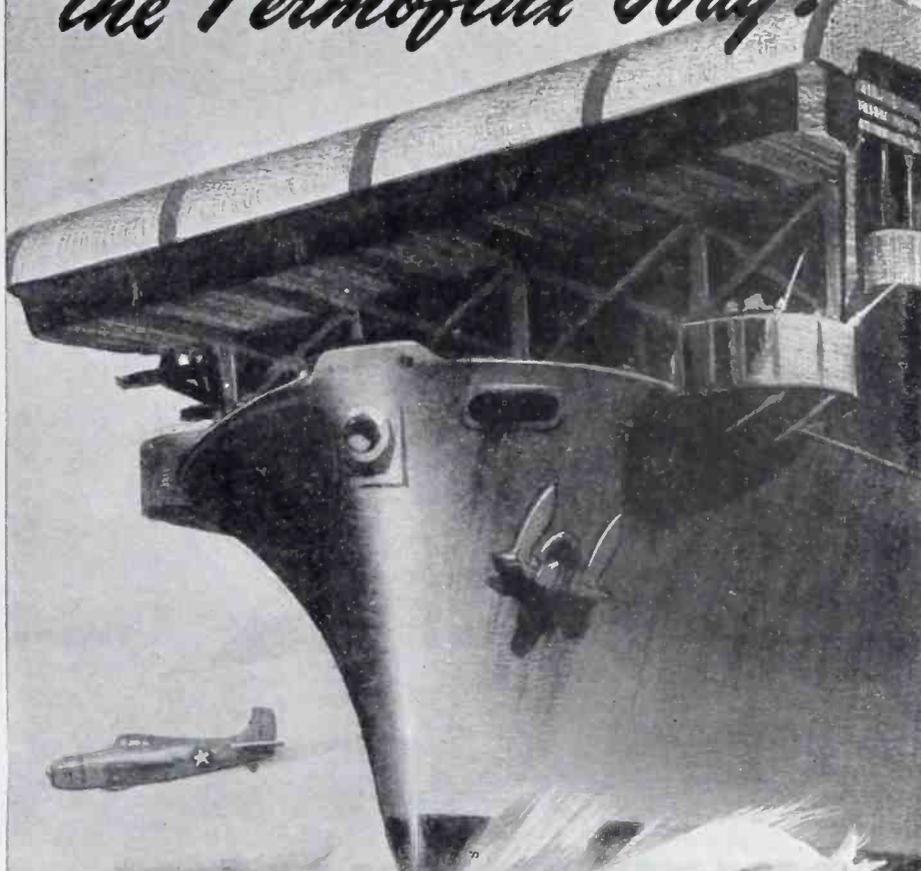
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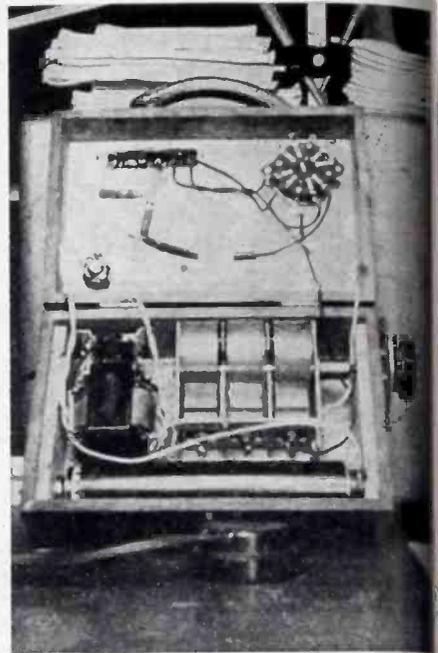
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• • •

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THE 300-FT ANTENNA used with the Gibson Girl emergency transmitter (shown on the cover of the September, 1943 issue of *ELECTRONICS*) is supported by a yellow kite made of steel and cambric. Combined with the transmitter, the kite is standard equipment on all bombers and transport planes.

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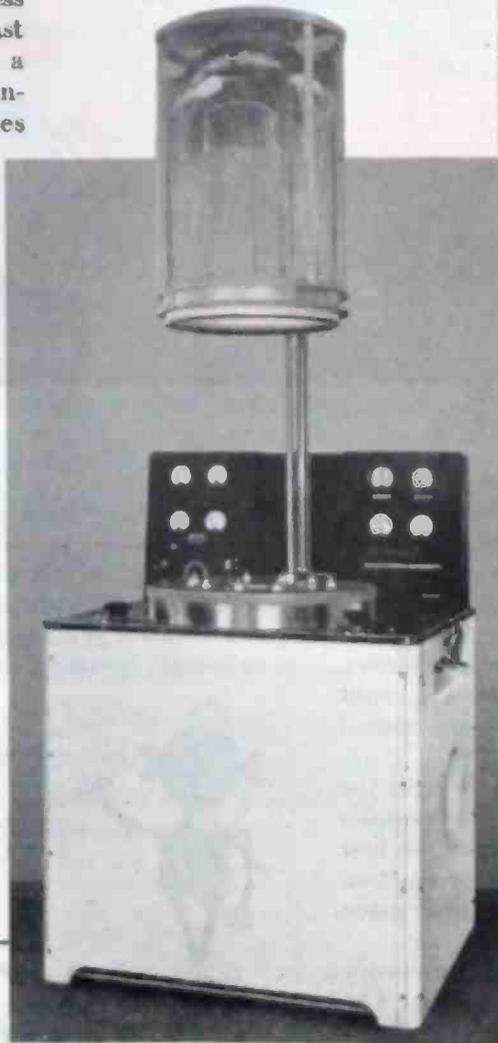
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This important new DPI unit is intended for the application of low-reflection coatings, or the depositing of metals such as silver, gold, aluminum, etc.—or metallic salts—on glass, metal, crystalline materials, and plastics.

FEATURES

- 1. Automatic bell-jar lift** For ease of operation.
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Write to DPI—Vacuum Equipment Division—for further details about this coating unit, or for information on complete vacuum systems to suit other needs.



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VACUUM EQUIPMENT DIVISION

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countered in the various war zones. Small corks are inserted in the open ends of the tubing to render them watertight.

The skirts of the kite are made of a water-repellent cambric that has a tensile strength of 39.4 on the warp and are given buoyancy by corner paddings of kapok. Controlled steel clamps which have also been given the corrosion tests hold the skirts to the frame.

A product of Hoffman Radio Corp. of Los Angeles, Calif., the kite can ride out a wind of 50 miles per hour and permits the transmitter to cover a range of 300 square miles in average weather. The kite stands 36 in. high when open and weighs but 12½ oz.

• • •

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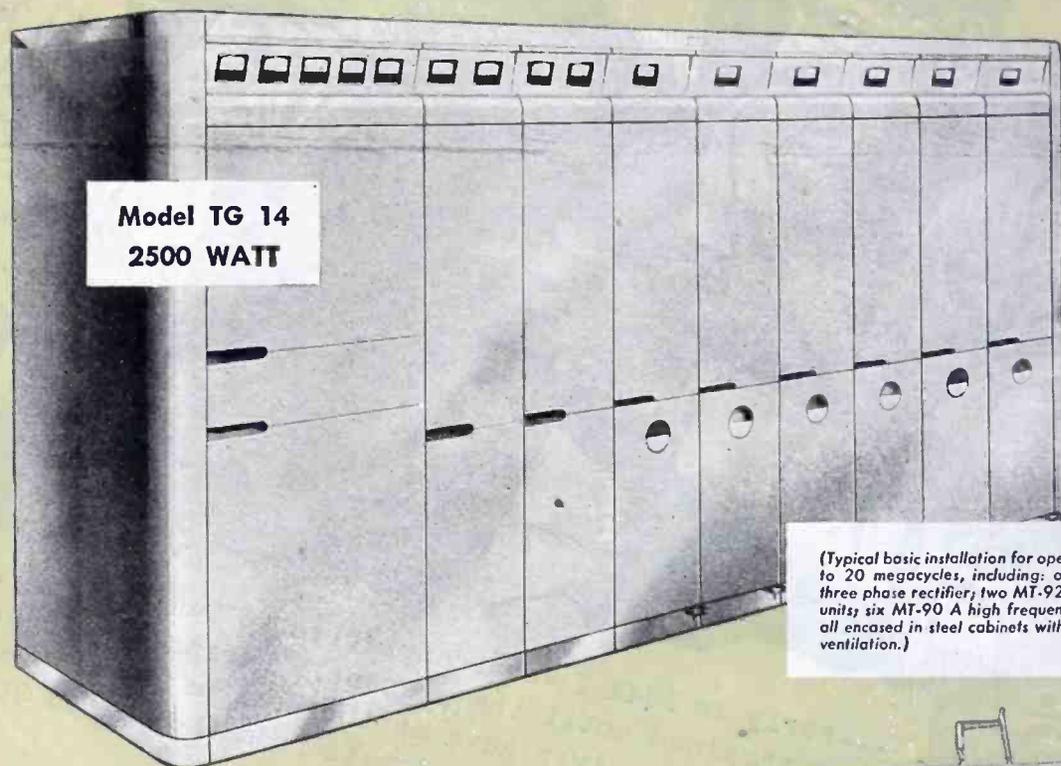
A photoelectric device automatically adjusts itself to the amount of light coming from the outside and shades the video screens to allow full daytime viewing.

An acoustical device adjusts the audio portion of the program to a level several decibels above street noises, projecting the sound only within the arcade area, thus overcoming the objection of the city fathers to sound amplification from store windows.

The postwar display windows are designed to utilize screens which are 18 x 24 in., with merchandise to be displayed around the screens. When larger screens become available, the windows could be adjusted to accommodate screens up to three-by-four feet and more.

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(Typical basic installation for operation on 2.5 to 20 megacycles, including: one MP-36 A three phase rectifier; two MT-92 A modulator units; six MT-90 A high frequency RF units—all encased in steel cabinets with forced draft ventilation.)

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Bendix Radio*—center of radio research and production for the aviation industry—has now turned its broad experience and extensive facilities to the production of the finest of ground station equipment—and here is one result: a new, unit-type installation providing an unlimited number of operating channels in the frequency range of 200-425 kc. and 2.5 to 20 mc. . . . with sufficient power supply capacity to permit simultaneous operation of 2 radio telephone, 1 radio telephone and 2 telegraph, or 3 telegraph channels . . . and designed to allow quick installation of additional RF channels as traffic loads increase.

Constructed to the quality requirements which have made the products of Bendix Radio the Standard of the Aviation Industry, this equipment has hermetically sealed transformers for tropical use, and is studded throughout with other features to assure peak performance under all conditions. As a further guarantee of reliability special attention has been given to adequate overload protection, and improved electrical design assures the effective reduction of Harmonic Radiation to a minimum.

Information as to dimensions, weight, construction, electrical characteristics and service features will be sent promptly on request.



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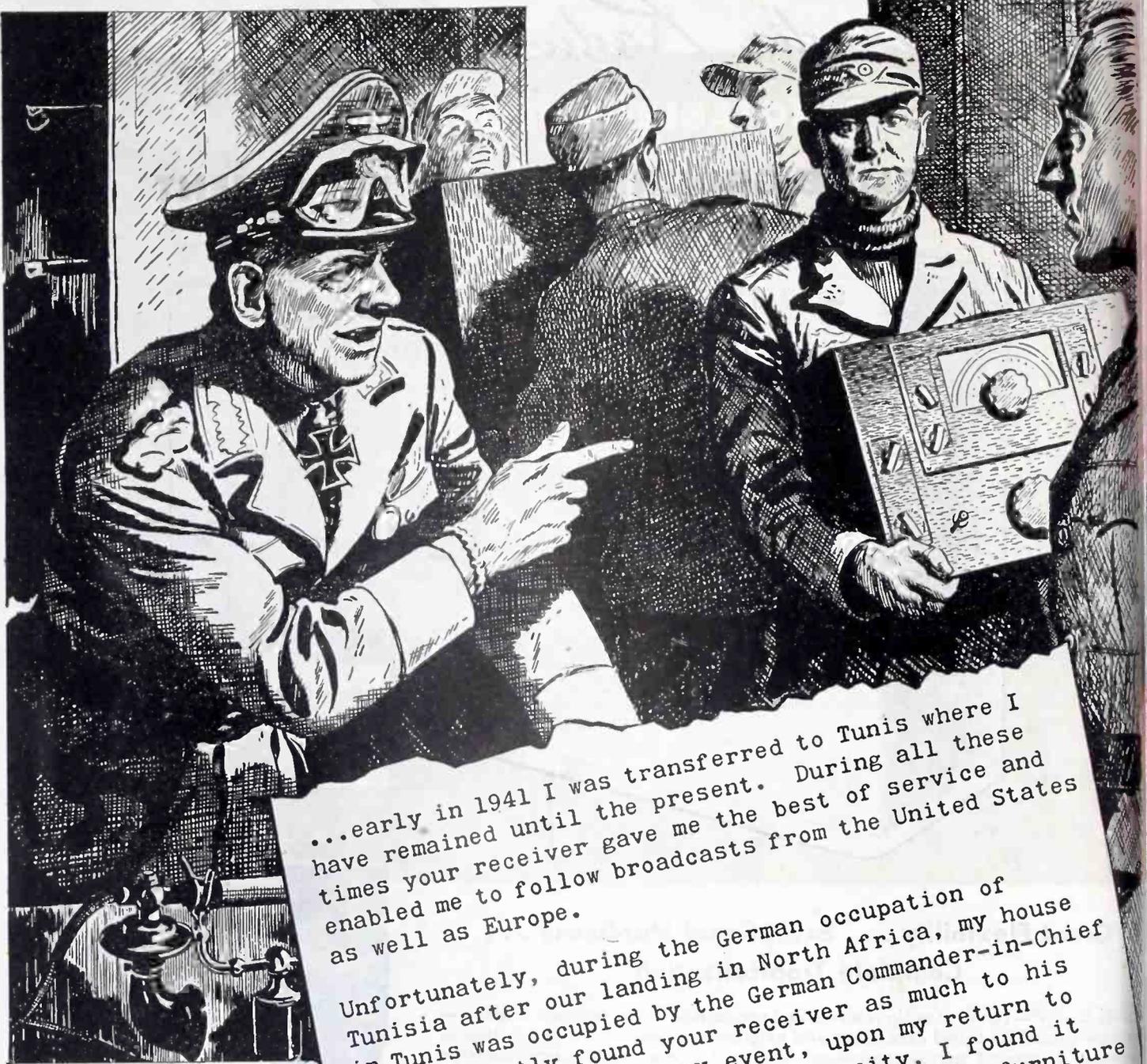
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BENDIX AVIATION CORPORATION BALTIMORE 4, MARYLAND

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...early in 1941 I was transferred to Tunis where I have remained until the present. During all these times your receiver gave me the best of service and enabled me to follow broadcasts from the United States as well as Europe.

Unfortunately, during the German occupation of Tunisia after our landing in North Africa, my house who apparently found by the German Commander-in-Chief liking as I had. In any event, upon my return to Tunis after the recapture of that city, I found it missing together with the greater part of my furniture and household effects.

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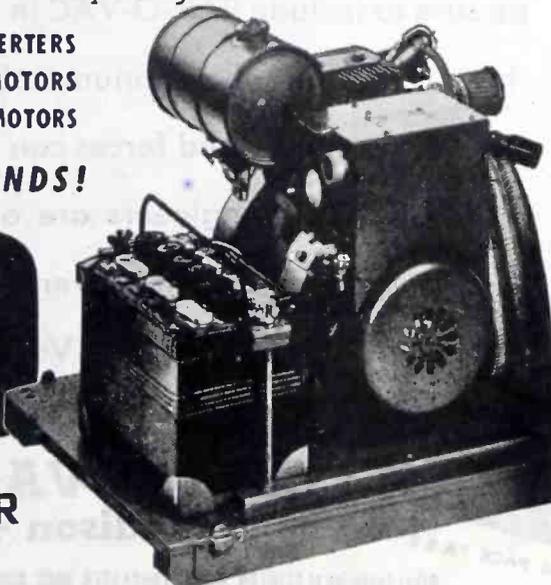
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Open-Grid Tubes

(Continued from page 128)

no case did omission of the grid leak lead to excessively high plate current or to high operating temperatures, nor did the grid bias become high enough to block the tube. In the ageing test, open-grid tubes also performed better than tubes with a grid leak. The noise is also less with a cathode resistor (of proper size) than without one. With a fixed bias resistor and variable plate voltage the least noise was obtained with a plate voltage of about 90 volts for a 6SJ7 tube.

Conclusions

If the tubes are to be operated with nearly zero grid bias the lowest noise level obtained by the omission of the grid leak is especially noticeable. From Table 1 it can be seen that for optimum grid bias the ratio of noise with a grid leak to the noise without a grid leak is 1.1 and for zero bias this same ratio is 1.97. This shows the advantage of operating without a grid leak for zero bias.

Operation of a tube without a grid leak seems practical in applications involving low-level operation with no d-c potentials in the preceding stage, and a negative grid bias of not more than about 2 volts.

Tests were also performed on pentode-connected 6SJ7 tubes and on 6J5 tubes, and similar results were obtained.

REFERENCES

- (1) Relch, H. J., "Theory and Application of Electron Tubes," McGraw-Hill Book Company, 1939, p. 184.
- (2) Everitt, W. L., "Communications Engineering," McGraw-Hill Book Company, 1937, p. 241.
- (3) Harris, W. A., "Fluctuations in Vacuum Tube Amplifiers and Input Systems," *R. O. A. Review*, 5, April 1941, p. 56.

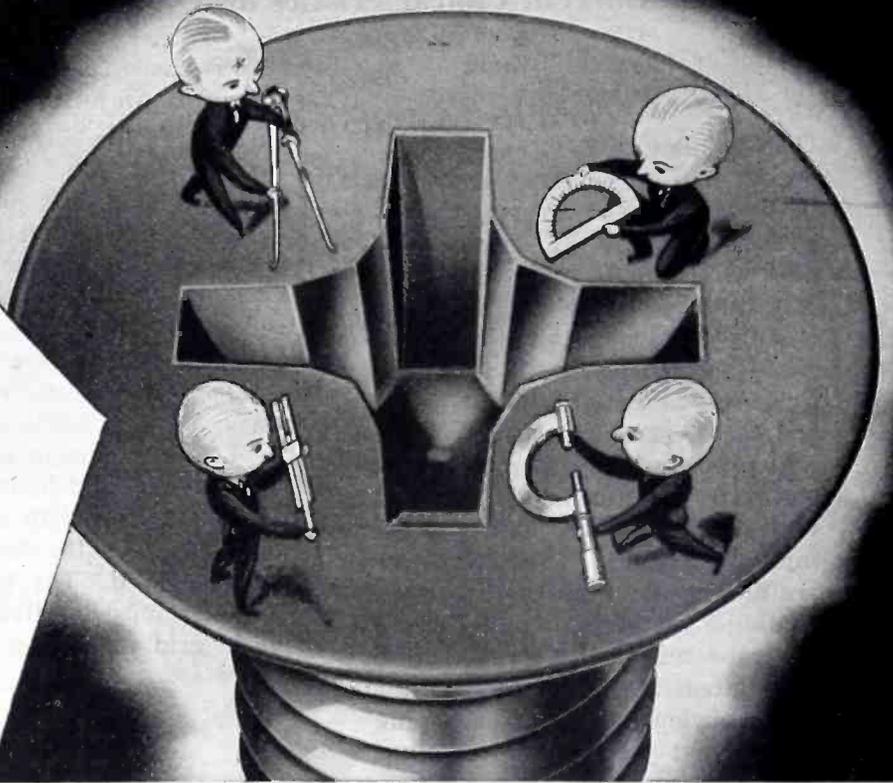
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- (1) King, Ronald, "A Screen Grid Vacuum Tube Without External Leak," *Proc. I.R.E.*, 22, June 1934, p. 771.
- (2) Moullin, E. B., "Spontaneous Fluctuations of Voltage," Oxford Univ. Press, 1938.
- (3) Terman, F. E., "Radio Engineering," McGraw-Hill Book Co., 1937, p. 224.

GIRL POLICE RADIO OPERATORS, Ruth Boddy and Jean Parnell, are employed by the Missouri State Patrol. They have been working at the net control station in Jefferson City.

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TAKE A LOOK at the center corners of the Phillips Recess above – and get a picture of some real screw engineering!

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Easier Driving: Turning power is fully utilized. Workers maintain speed without tiring.

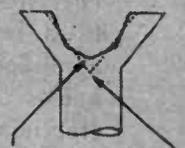
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Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Wolverine Bolt Co., Detroit, Mich.

THE ELECTRON ART

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Grid-Current Characteristics of Typical Tubes

By **LOWELL W. ZABEL**
Radio Engineer
Wilcox Electric Co.

DURING THE PAST few years, considerable interest has been shown in the applications of vacuum tubes to such problems as the measurement of direct voltage and current. In particular, tubes have been used in stabilized vacuum-tube voltmeter circuits which have sufficiently high input resistances that little effect is had on the measured circuit. Likewise, vacuum-tube microammeters and micro-microammeters such as that of A. W. Vance* require high input resistances. These problems are the same as those met when designing a phototube amplifier where the tube must react to very low light intensities.

The obvious method of obtaining high input resistance combined with high stability is to use specially designed low grid-current tubes in a balanced degenerative circuit. However, in many instances the relatively high cost of such tubes and the lack of necessity of the use of extremely high values of input resistance make it desirable to seek some more readily available and less expensive tube. Since data concerning the grid current characteristics in the negative grid region is not available for the more common tubes, it is the purpose of this article to give some data on a few receiving type vacuum tubes.

The measurement of the minute currents that flow in the grid circuit of a negative-grid, direct-current amplifier must be done indirectly unless a very sensitive galvanometer is available, and even then the grid current of the best of the receiving-type tubes can not be measured. The indirect method which was used to obtain the data given

here can be made fully as accurate. The circuit shown in Fig. 1 is used.

Method

The procedure is first to run the grid-voltage vs plate-current curve for the tube in question, using the same values of plate, screen (if a pentode) and heater voltage under which it is desired to operate. At a given value of E_c , the plate current is read on M , with S both open and closed. The difference in plate current with and without R_0 in the circuit can be converted to a change in grid voltage from the static curve previously plotted. The grid current is determined by dividing the change in grid voltage by the grid resistance R_0 .

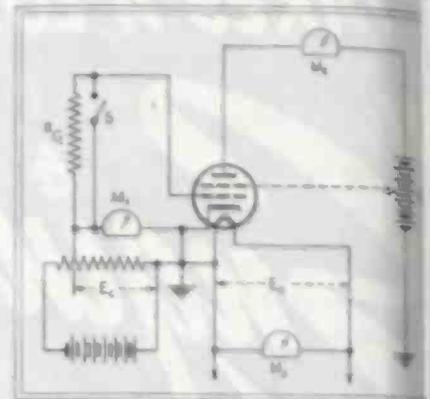


Fig. 1—Circuit used in obtaining data for curves of grid-current characteristics by the indirect method

The accuracy of the method depends on the accuracy of the plate current and grid bias meters and the accuracy to which the grid resistance is known. The overall accuracy can quite readily be kept within ± 15 percent.

The tube types selected for measurement are all readily available and are considered representative types. The curves of Fig. 2 show the grid current I_g that may be expected from an average 6J5 triode. These curves show that some improvement can be obtained by lowering the heater voltage below the

TESTING FOUR-IN-ONE DYNAMOTOR



Test panel for Westinghouse dynamotors having four separate output voltages from 14 to 300 volts. Output voltages are held constant for normal input-voltage variations by a regulator field which weakens when the input voltage rises and strengthens when the voltage drops

* Vance, A. W., *Rev. Sci. Inst.*, 7, 489, 1936.

OHMITE

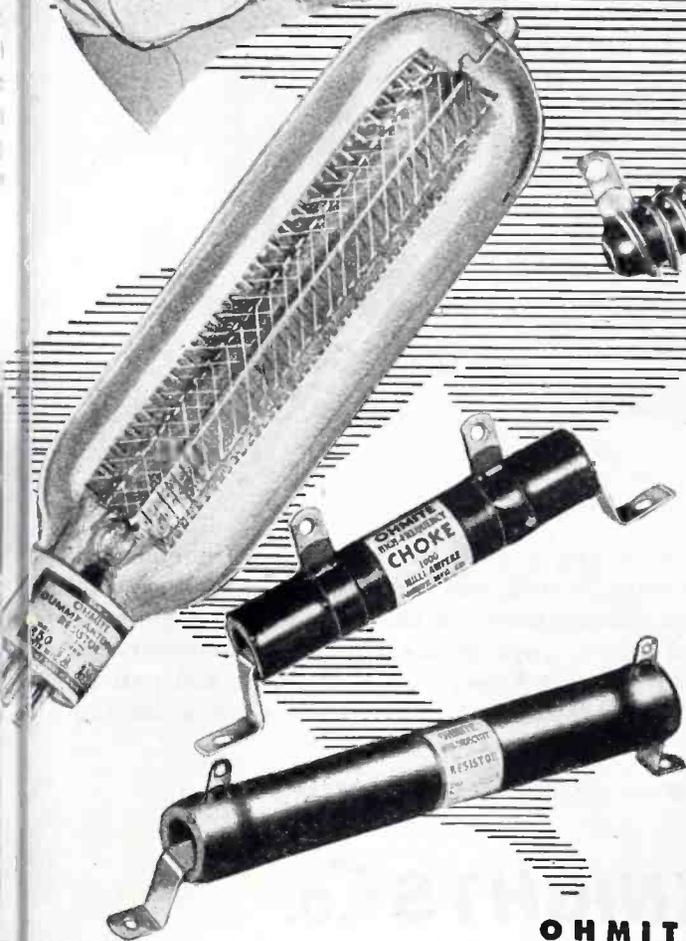
RESISTORS and CHOKES

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Here's what *COLLINS RADIO CO.*, well-known transmitter manufacturer, says: "*Within its power range . . . the most convenient to use, the most stable and the most accurate Dummy Antenna we have encountered . . . Used successfully for testing and measuring power output . . . Gives long life without detectable deterioration.*"



Proved by use before war came . . . Ohmite R.F. Units today are performing vital functions in the production and operation of vital war equipment. An interesting example is the use of Ohmite hermetically-sealed, glass-enclosed gas-filled dummy antenna resistors by Collins Radio Company, and other well-known manufacturers for testing and measuring power output.

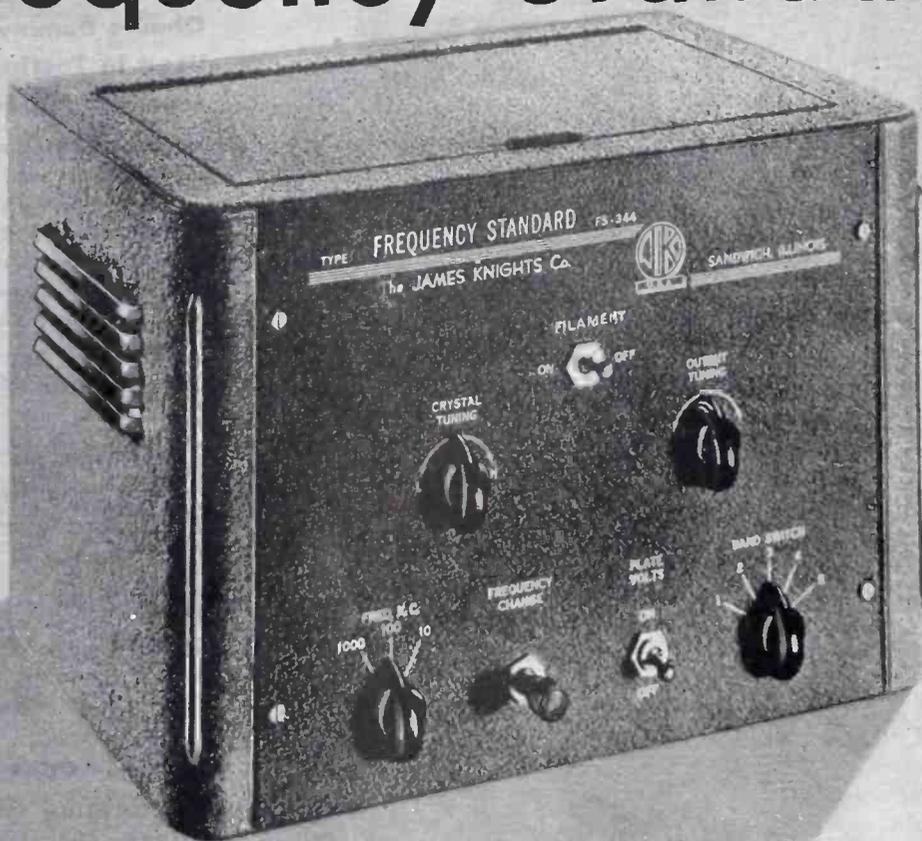
Other Ohmite Units doing specialized jobs in radio frequency applications are Vitreous Enamelled Non-Inductive Power-Size Resistors, Parasitic Suppressor and R.F. Plate Chokes.

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This is the ideal secondary frequency standard to check frequency of oscillators and transmitters, to calibrate and align receivers, etc. Can be used by the crystal manufacturer to check frequency standards for production. Useful many ways in the electronic laboratory or factory. Provides output up to 40 megacycles at 1,000, 100 and 10 kilocycle intervals. Complete cost only \$59.50. Descriptive catalog sheet on request.

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**BH EXTRA FLEXIBLE
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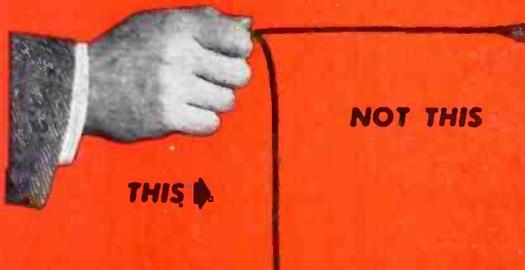


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*Here's an Insulation that Handles Easier,
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IF you're exasperated by ordinary sleeving that frays on the ends, works stiffly and doesn't hold up in use . . . then you'll certainly want the low-down on BH *Extra Flexible* Fiber glass Sleeving! For this is a really *flexible* and definitely *non-fraying* sleeving—built around the excellent insulating qualities of Fiber glass by an *exclusive* BH process.

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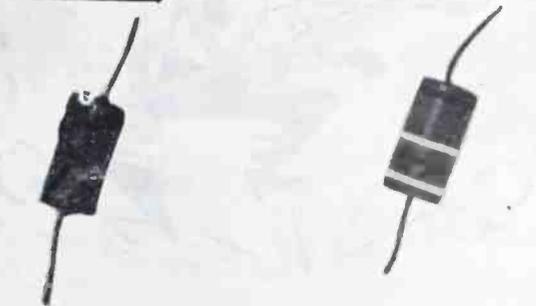


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After 5 days' actual exposure

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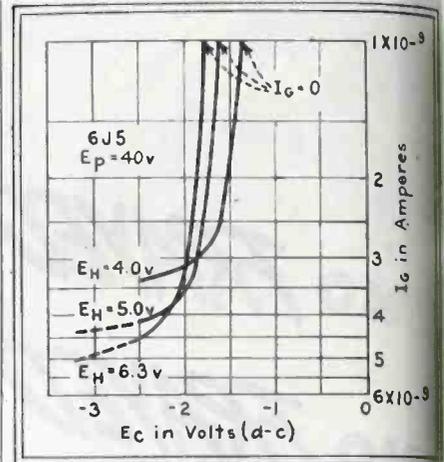


Fig. 2—Grid-current curves of a 6J5 tube with 40 volts applied to the plate

rated 6.3 volts. It is probable that decreasing the voltage below 4.0 volts would result in still more reduction of grid current, but at such a low heater temperature that plate-current saturation is easily reached. Operation of a tube near the maximum emission results in instability, therefore it is advisable not to reduce the heater temperature too far.

Need for Low Voltage

Figure 3 is a similar set of curves for a 6SJ7GT connected as a pentode. Here the variable parameter is plate and screen grid voltage. The curves make it quite obvious that for low grid current it is to a decided advantage that the highest voltage present within the tube envelope be not much greater than 40 volts. Higher voltages than this cause slight ionization of the minute amounts of gas remaining

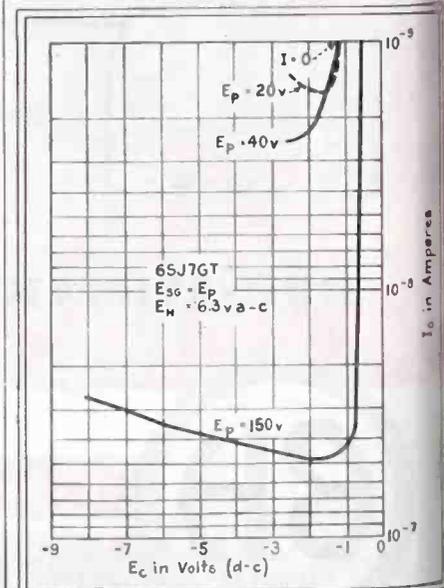
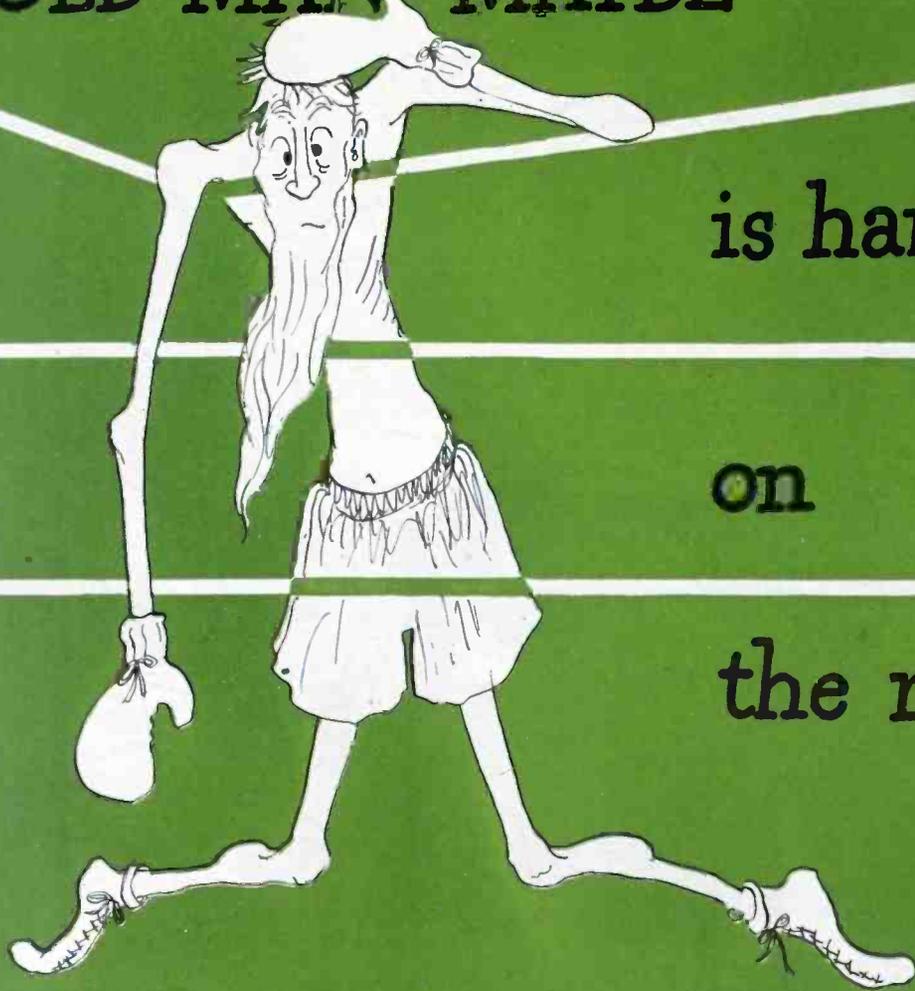


Fig. 3—Grid-current curves for a 6SJ7GT connected as a pentode

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on

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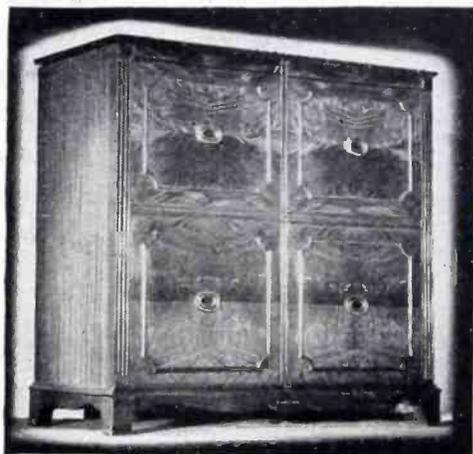
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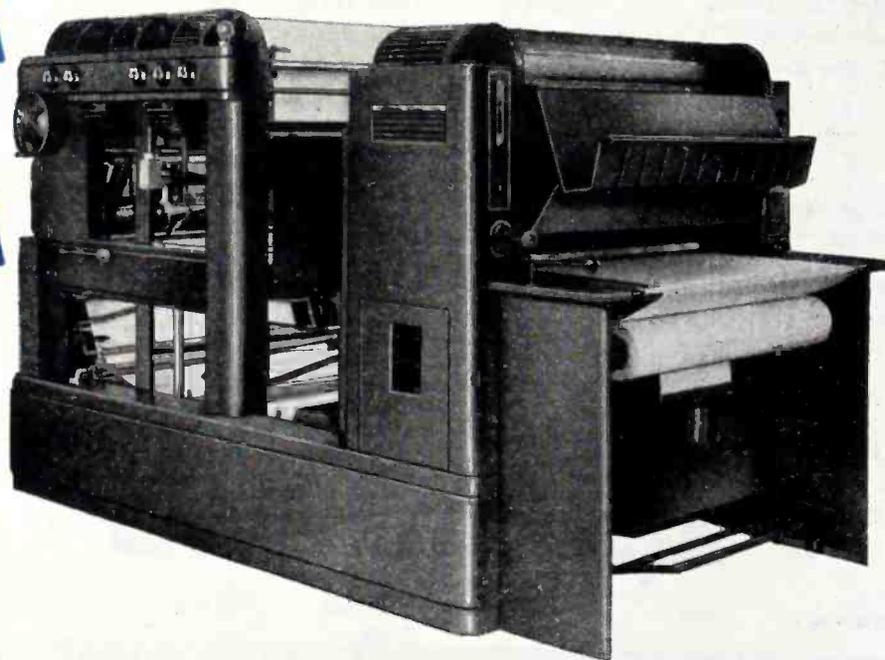
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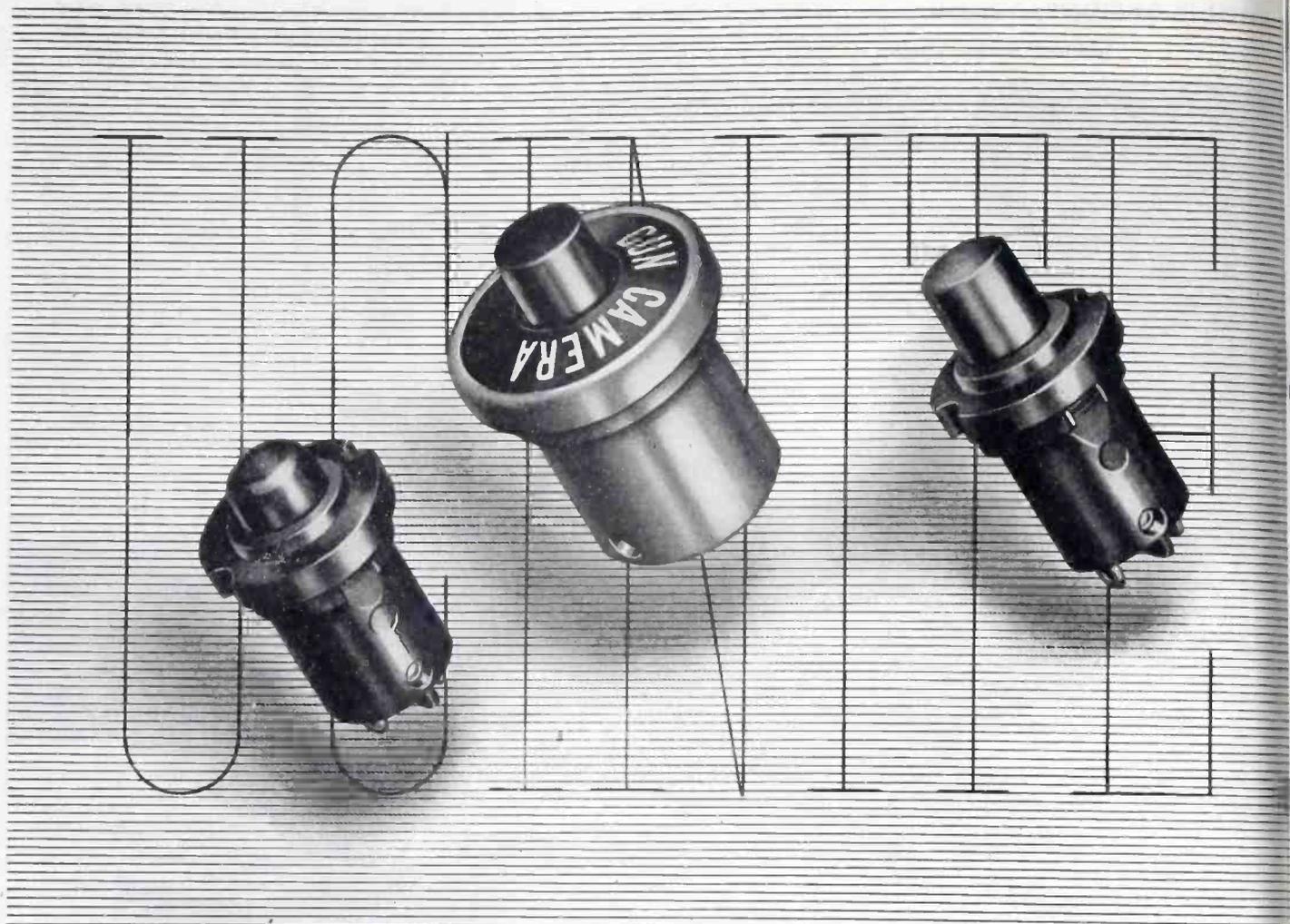
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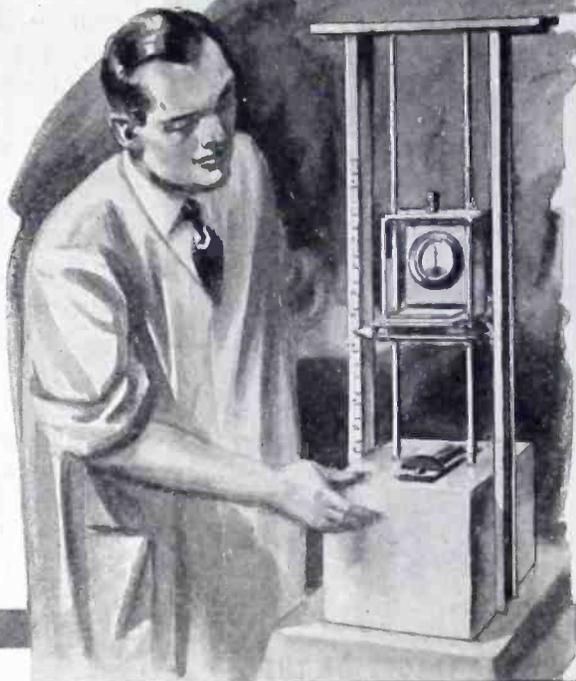
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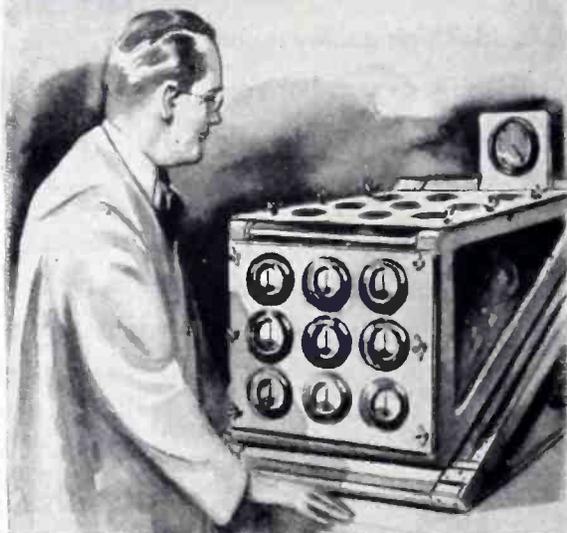
Simpson Shock Test—Instrument is mounted in sliding carriage, and dropped against bottom plate. Vertical scale permits shock of impact to be computed in multiples of g, the acceleration of gravity.

WHILE electrical instruments are delicate by their very nature, the conditions under which they must serve are seldom ideal—these days especially. Before entrusting them with vital responsibilities, it frequently becomes necessary to learn just how much abuse they can withstand.

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SIMPSON ELECTRIC COMPANY
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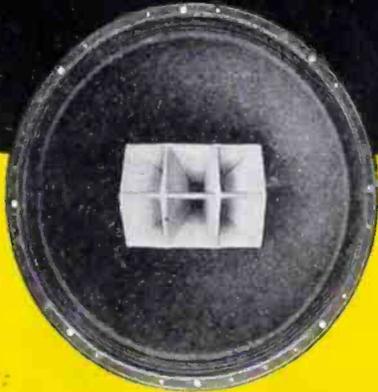
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to the point $I_g = 0$, and the other is zero plate current.

In order to have stable operation, it is necessary to use a grid circuit resistance sufficiently small that the IR drop across the grid resistance is small compared to the available grid swing. As an example, if the 6J5 of Fig. 2 were to be used it would not be advisable to attempt to use a grid circuit resistance greater than 25 megohms. With this grid resistor, the loss of bias due to grid current is a maximum of 0.1 volt. In many cases, this loss can not be tolerated and even less grid resistance can be used.

Comparison

Figure 6 is probably the most significant set of curves presented. This shows the magnitude of variations in grid current that may be expected from tube to tube. Tube No. 1 is the best of a group of 12

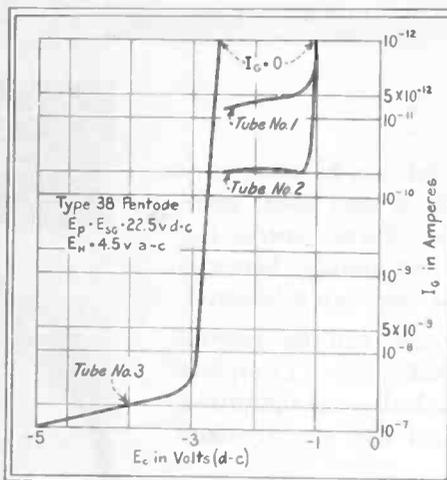


Fig. 6—Curves of grid current obtained from three tubes of the same type

type 38 tubes purchased about three years ago. Tube No. 2 is an average tube and tube No. 3 is a very poor tube which was purchased recently. This is not meant to infer that tubes of recent manufacture are poorer with respect to grid current than older tubes since only two recent tubes were available for test. It is quite obvious from this data that the type 38, on the average, shows superior grid-current characteristics.

Two tubes, whose grid current approximated that of tube No. 1, were used in a balanced bridge circuit for measuring small light intensities falling on a pair of type-929 phototubes. The amplifier was stable, and reliable data was ob-



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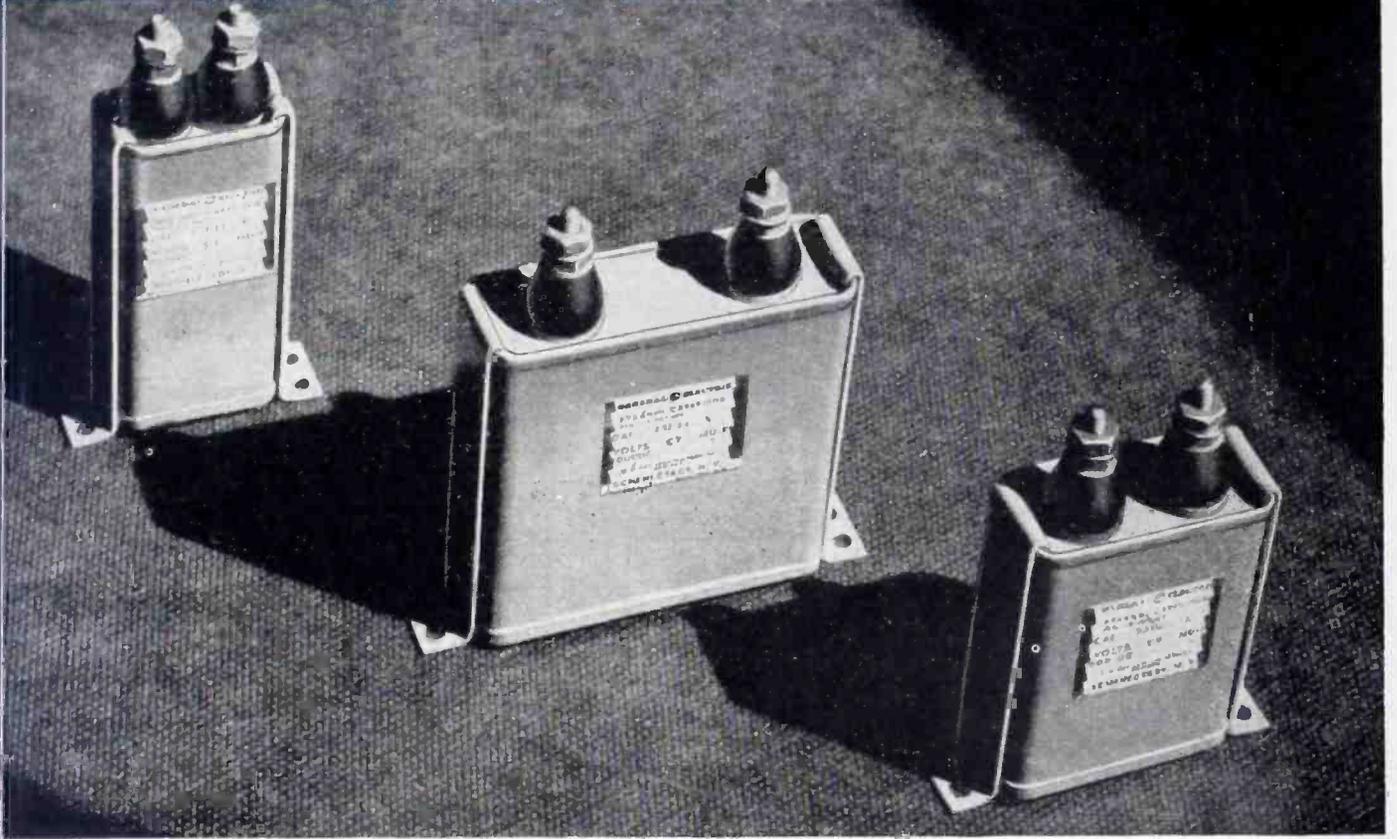
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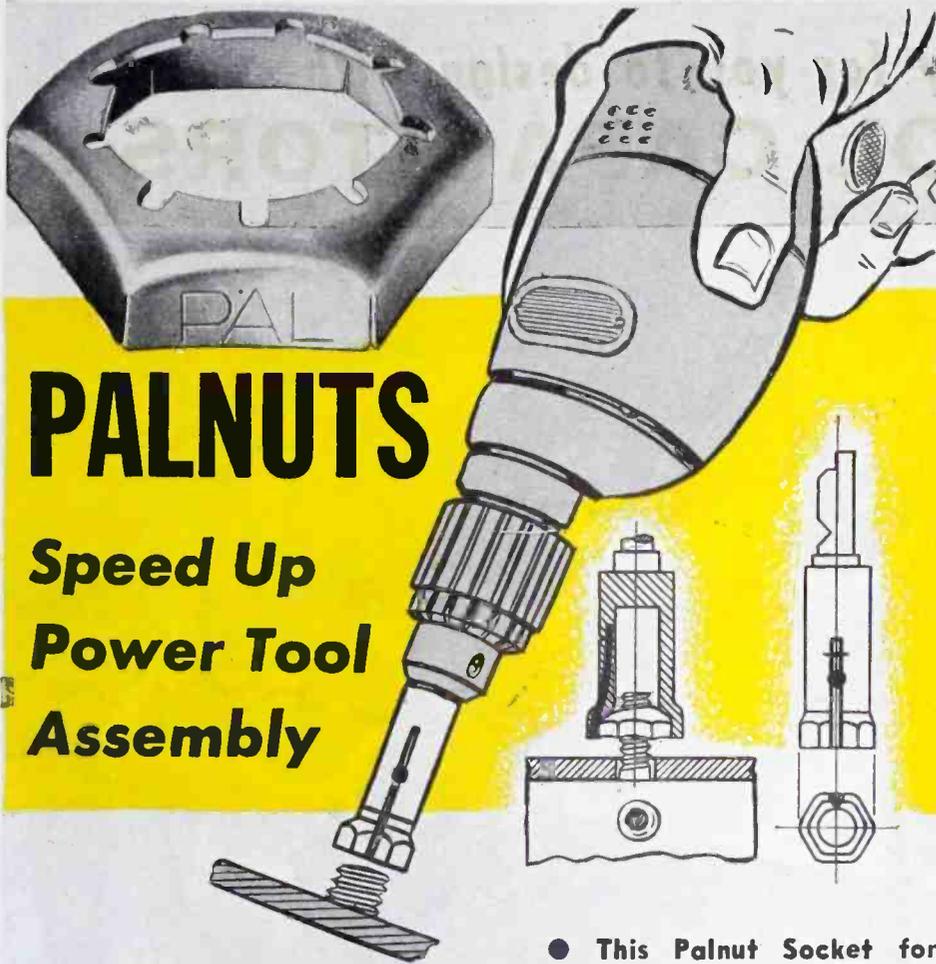
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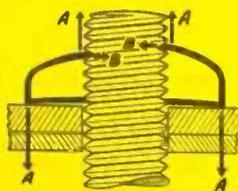
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tained at light levels which gave a photo current of approximately 10^{-10} amperes. A grid circuit resistance of 5×10^8 ohms was used.

It may be concluded from this data that grid circuit resistance up to a possible maximum of 5×10^8 ohms can be used with a number of the common receiving type vacuum tubes. If it is necessary to go higher than this, it will be necessary to pick the tubes to be used by actual measurement of grid current and to operate the tubes at a plate voltage not exceeding about 40 volts and a heater or filament voltage 20 percent below normal.

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Brain Current

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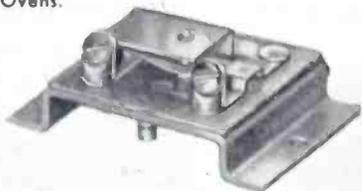
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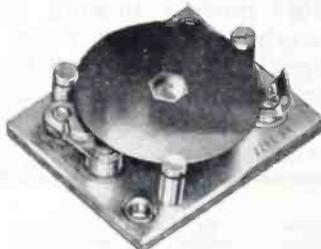
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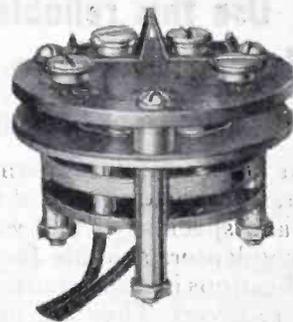
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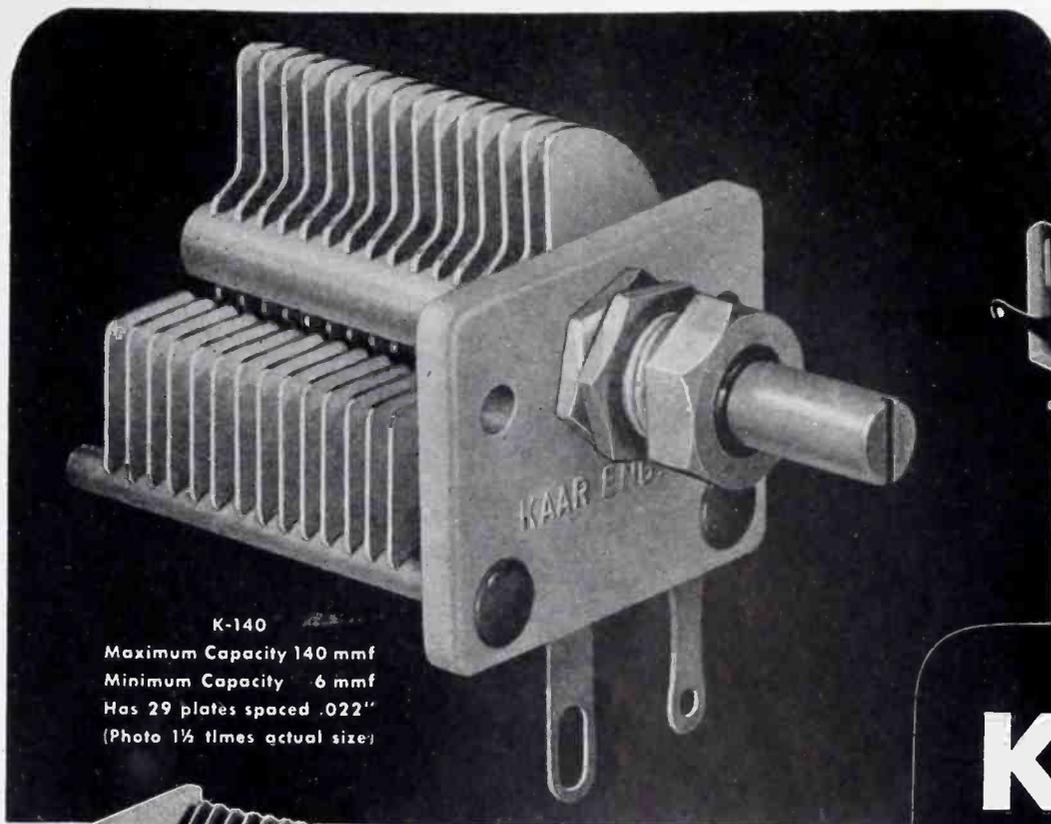
Type ER Series. Ambient Compensated Time Delayed Relays.



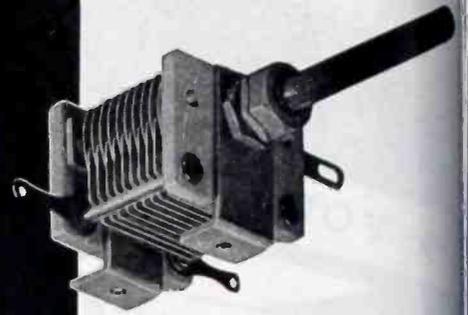
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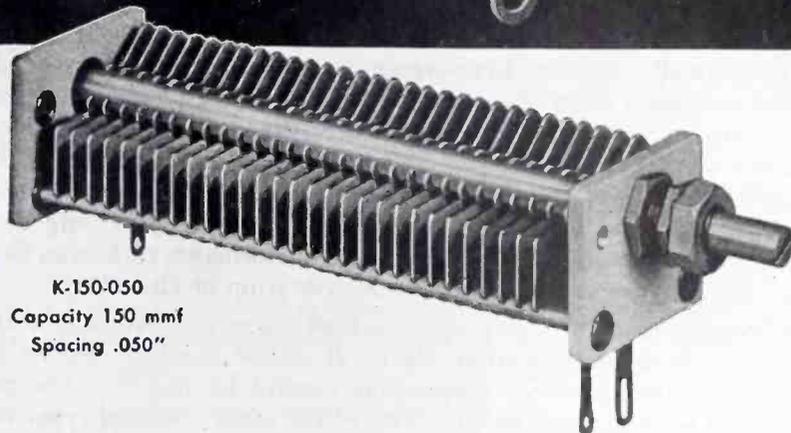
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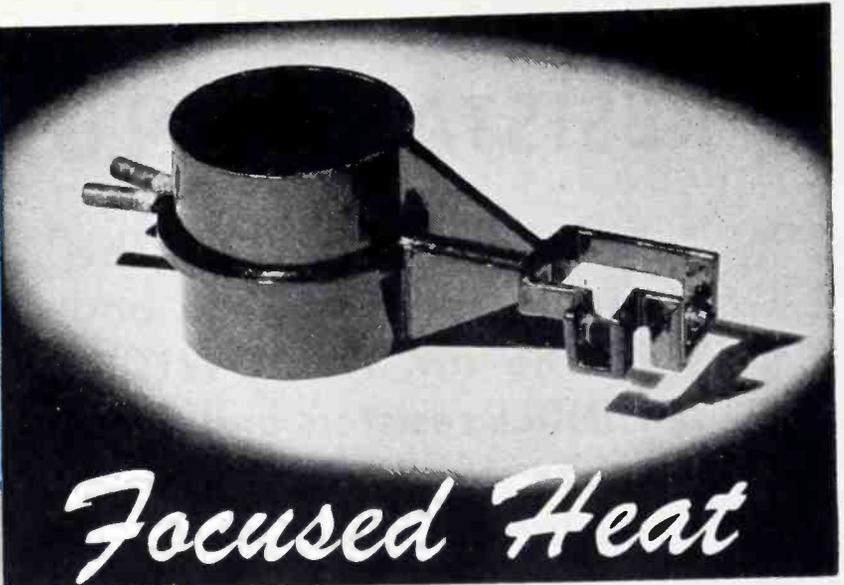
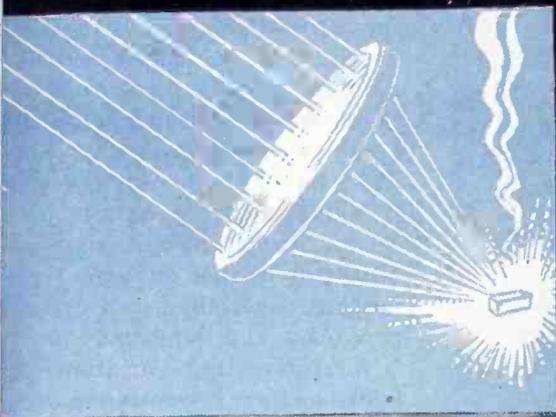


MICROPHONES—Type 4-C single button carbon. Superb voice quality, high output, moisture-resistant.



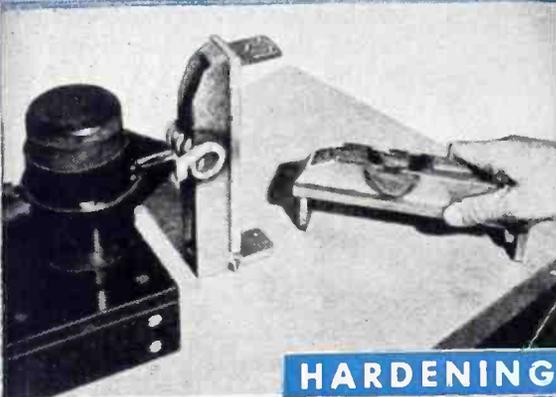
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with AJAX-NORTHRUP



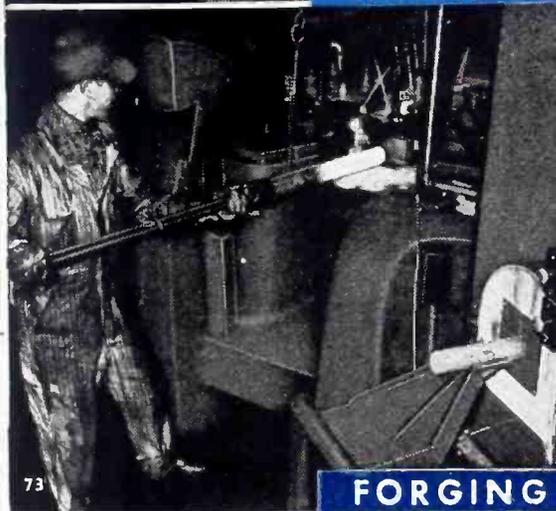
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The little coil pictured above focuses 6 kilowatts of high-frequency current into a small complicated joint, and produces perfectly brazed bourdon gauge parts at an amazing rate of speed — at low unit heating cost, with no distortion and no clean-up required.



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Aptly named a focus inductor, the coil was designed by Ajax-Northrup engineers to control and accurately concentrate the heat — no need to heat the whole part just to braze one small joint.



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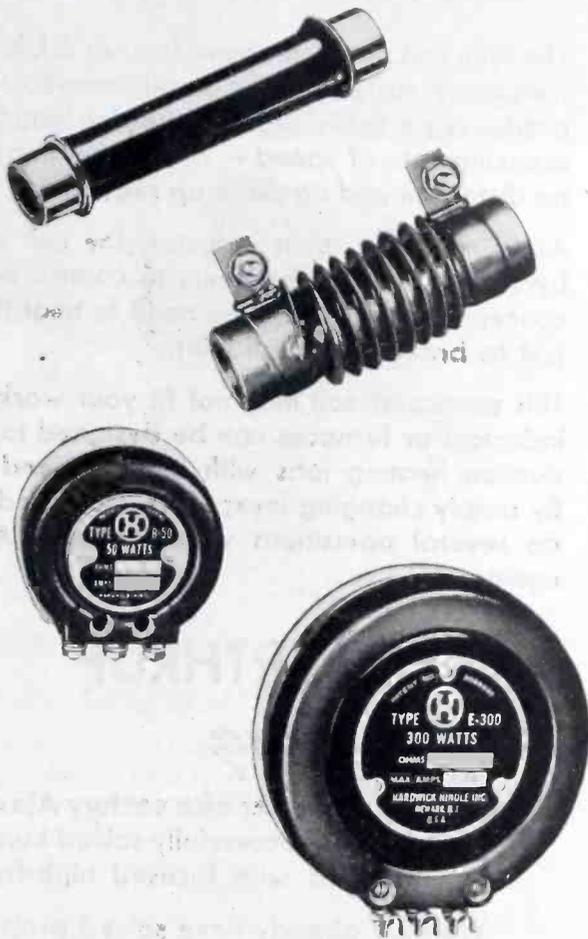
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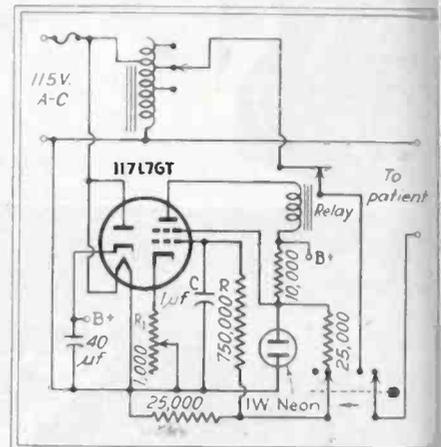
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flowing through the scalp. When the current is applied, the patient goes into a convulsion closely resembling an epileptic seizure, which ceases in a few seconds. He usually becomes conscious in 9 or 10 minutes, but remains somewhat confused for about a half hour. Excellent results have been reported with this method in some types of insanity especially manic depressive psychosis and schizophrenia.

An interesting variation of the above method is electronarcosis, described by Drs. Frostig, van Harreveld, Reznick, Tyler, and Wiersma in the *Archives of Neurology and Psychiatry*, 51: 232-242, 1944. In 1902, Leduc produced electronar-



Circuit of electronic timer for control of therapeutic electric shocks. The neon bulb is used as a voltage stabilizer in the screen-grid circuit

cosis in dogs by passing a unidirectional pulse current from the head to the sacrum, and later tried it on himself, with the assistance of Malherbe and Rouxeau. After the application of the electrodes, the current was slowly increased. At a low level there was considerable discomfort at the site of the electrodes, which ceased on further increase of the current. He soon lost his ability to speak, and at a slightly higher level was unable to move. He heard what was said to him, but understanding was dreamlike and painful stimuli felt dull and far away.

About 1910, electronarcosis was used as a method of anesthesia in a few clinical surgical operations with some success. The present study was apparently not made with electrical anesthesia especially in view, but to elucidate further the physiology involved. The first experiments were performed on dogs,

ELECTRONIC HEAT SPEEDS CURVED SECTION GLUING

Mass-production Method Promises Savings in Cabinet, Furniture, and Piano Assembly

High-speed quantity production of both flat and curved laminated sections is now practical with the aid of electronic heat to speed gluing. This conclusion is based on extensive war-time application experience which shows that on large-production items, electronic heating offers definite economies.

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RCA ELECTRONIC HEAT

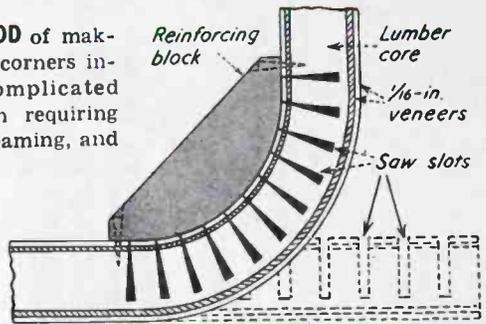


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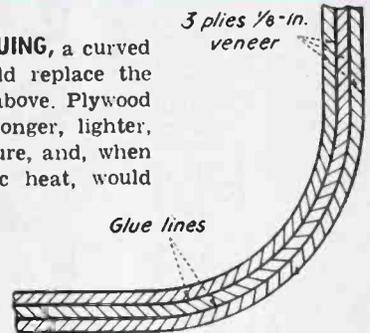
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THIS METHOD of making curved corners involves complicated construction requiring slotting, steaming, and bending.



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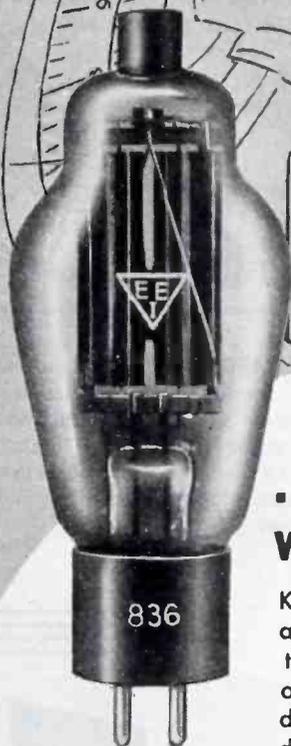
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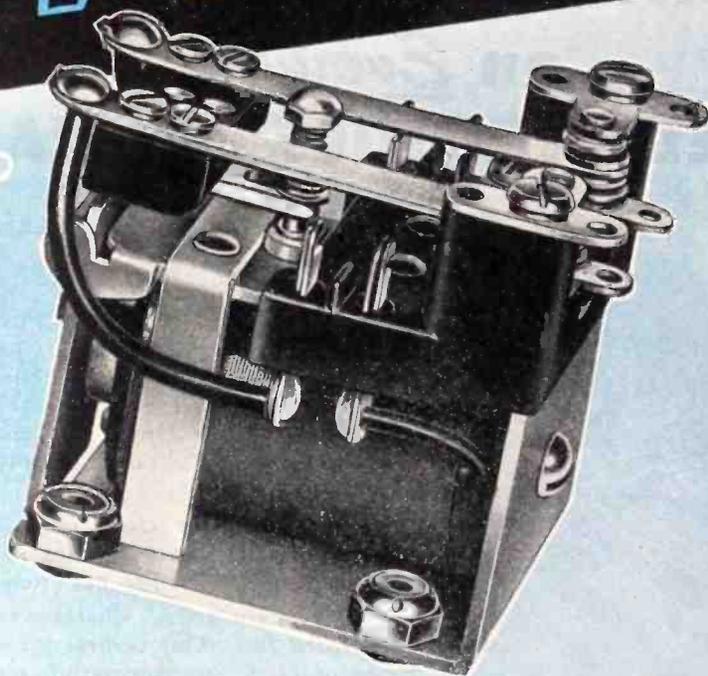


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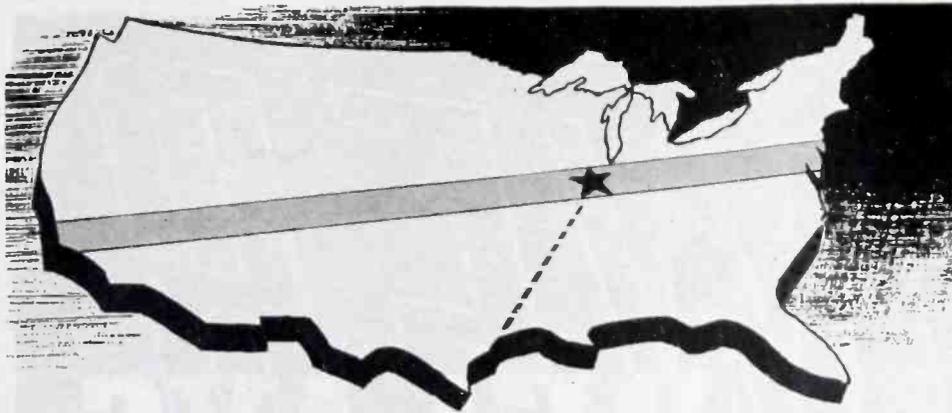
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the later experiments on schizophrenic patients as a variant of standard electroshock therapy.

Apparently any current capable of stimulating the central nervous system can be used to produce electronarcosis. This requires a moderately rapid variation of current duration and slope, repeated at suitable frequency. Sixty or fifty cycle alternating current is more generally available, so all of the experiments were done with this power source.

Effect on Humans

In the dog, it was found that the symptoms shown on application of the current were quite variable, ranging from a quiet narcosis to violent convulsions. In man, there are always some convulsive symptoms present but they never reach the intensity shown in the dog. The initial current used was 150 to 200 ma for thirty seconds, after which it was decreased to a point where respiration returned, between 100 and 90 ma. Nine schizophrenic patients were used as the subjects of the human experiments and a total of over 100 electronarcoses were induced. All had shown signs of dementia praecox for over four years and were physically healthy.

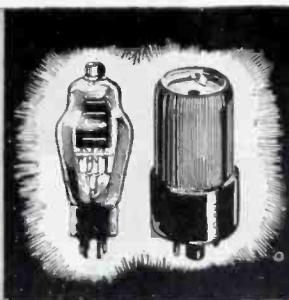
Application of the current was immediately followed by a lightning-like movement of the arms and legs, followed by a phase of rigidity. The chest was fixed in a position of maximal inspiration and there was complete arrest of respiration during the high initial current flow. It usually resumed after reduction of the current to the lower prolonged level, but was sometimes delayed for a total of 50 to 70 seconds. The heart stopped beating for a few seconds after current flow started and then started again at a low rate, about 20 per minute. The eyes were closed and the pupils were constricted and did not react to light. In women, an erection of the nipple occurred.

When the current was decreased the rigidity ceased and there were usually a few seconds of coarse shaking and clonic twitches. The patient was then in a relaxed stage for three to five minutes. Spontaneous movements, primitive in character, appeared thereafter. The schizophrenic patient tried to roll over or slip up. Reflexes, which had been ab-



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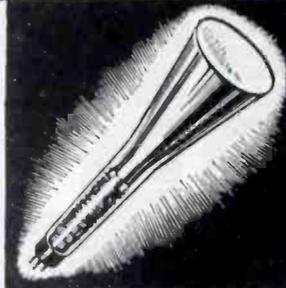
◀ TRANSMITTING TUBES

◀ FACSIMILE RECORDING TUBES



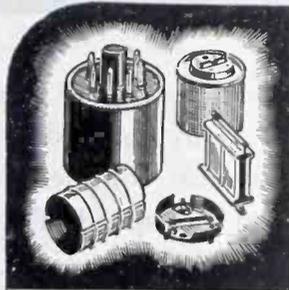
▲ MINIATURE RADIO RECEIVING TUBES

◀ CATHODE RAY TUBES



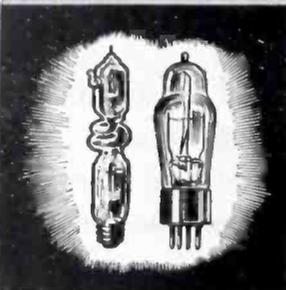
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MINIATURE AND STANDARD SIZE



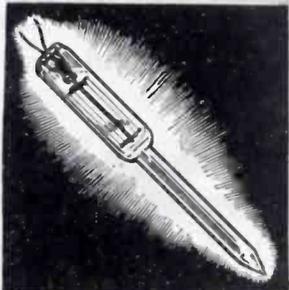
▲ RADIO TUBE PARTS

▶ STROBOTRONS



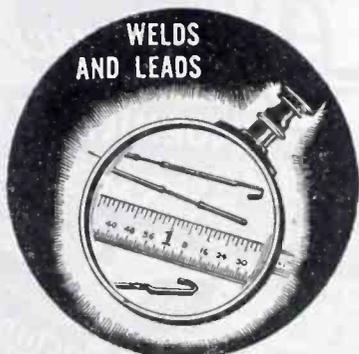
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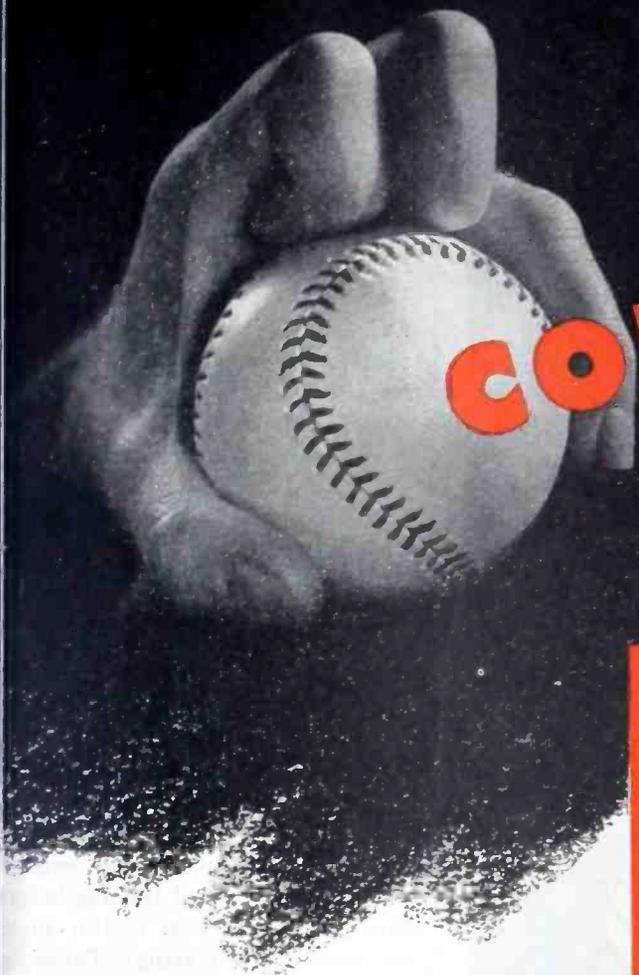


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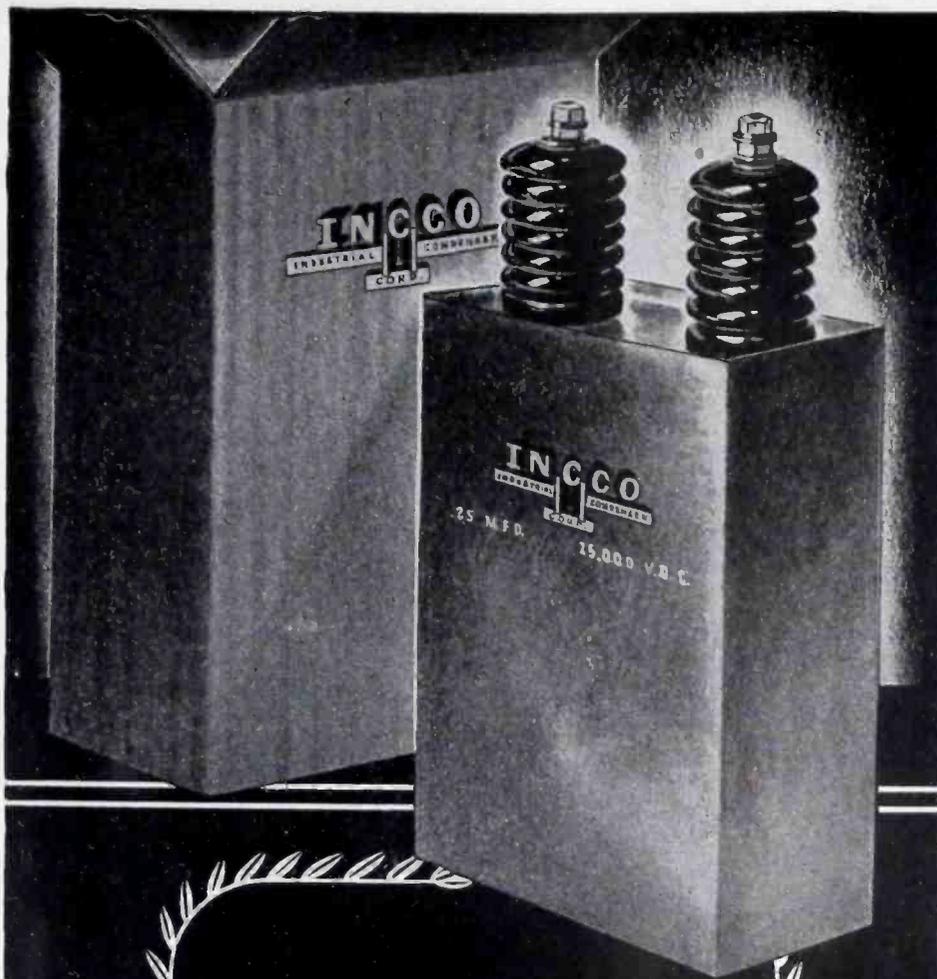
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sent during the earlier period, began to reappear. The pupils began to react to light. After the initial symptoms had passed, the respiratory and heart rates were considerably higher than normal.

Subject's Sensations

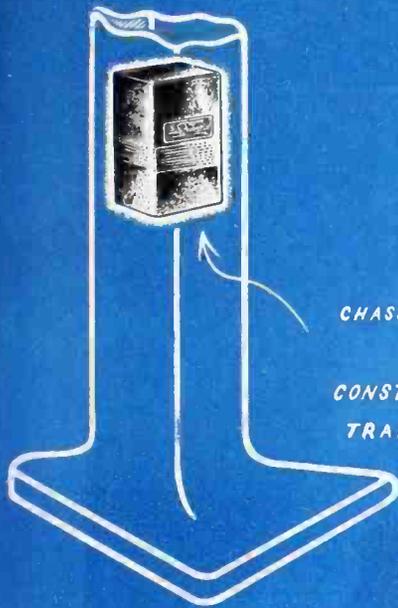
The patients were unconscious during the entire applications of the current, but some patients stated that they remembered a flash of light at the beginning of the treatment, which may have been due to the stimulation of the optic system by the high initial current. It is interesting to note that according to the results obtained in electroshock therapy an electronarcosis, electrocution is apparently completely painless. No patient reported any unpleasant sensations during electronarcosis. A few minutes after termination of the treatment the patient usually reacted to his name and a few minutes later tried to answer questions.

In the dog, the placement of the electrodes had little effect on the results, which would be expected because the brain of the dog is quite small in comparison to the muscular and bony covering. These factors tend to equalize the current flow in various parts of the brain.

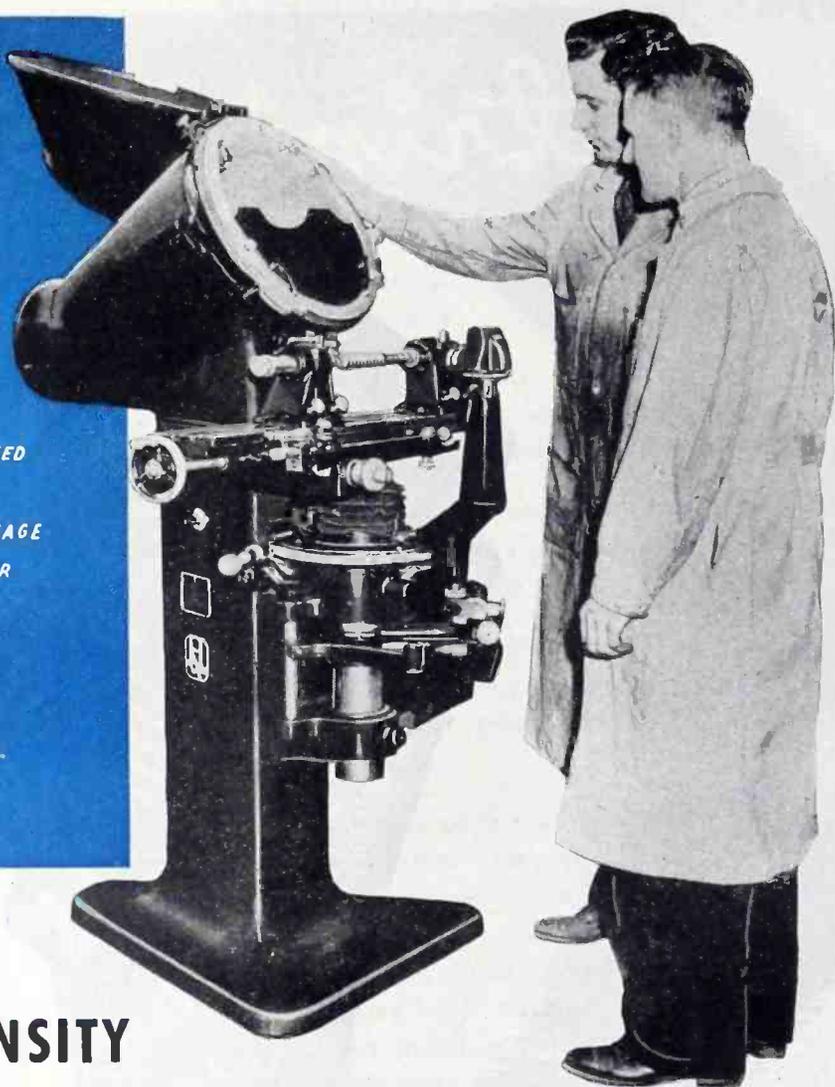
In man, the main symptoms of electronarcosis were unchanged by the placement of the electrodes, but there were minor differences. Lower placement of the electrodes caused a profuse secretion of saliva and tears, which was not present with the electrodes higher on the head. With the electrodes over the frontal part of the skull, the pupils were constricted and did not react to light in the first period of the electronarcosis. With the electrodes farther to the back, the pupils were less constricted and reacted to light earlier. With the occipital location, there was greater respiratory depression than with the frontal location.—W.E.G.



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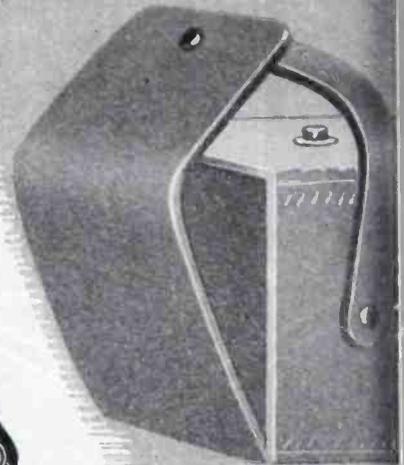
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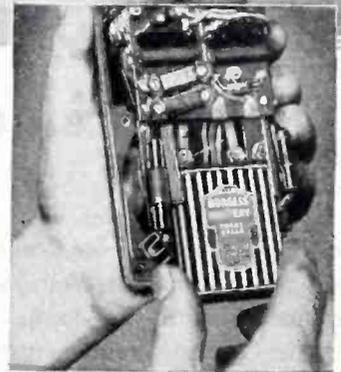


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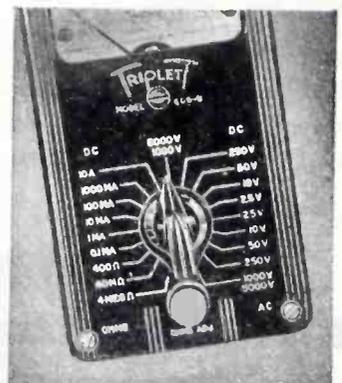
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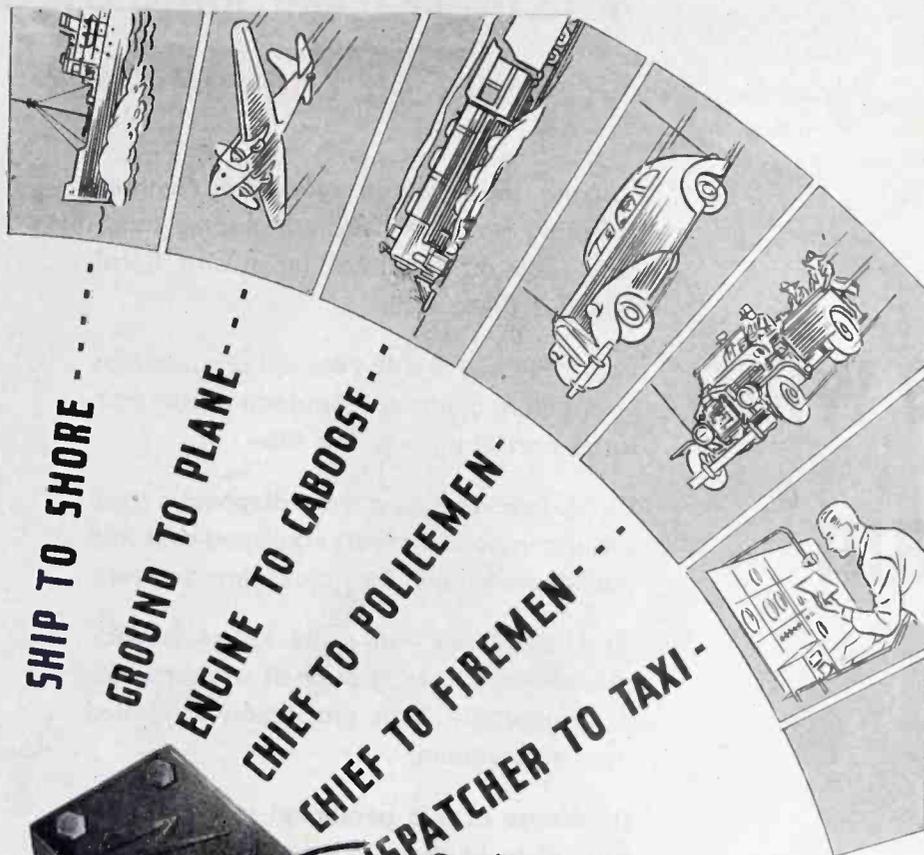
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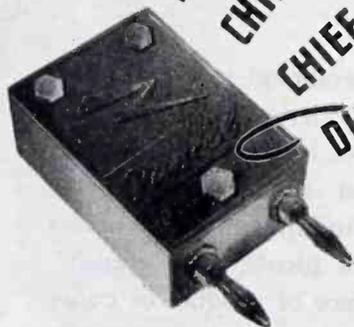
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QUANTITY PRODUCERS OF STANDARD AND SPECIAL

Control Crystals

Capacitor Plates

(Continued from page 136)

one that makes E a minimum.

Adding T to both sides of Eq. (17) gives

$$S + T = \frac{v}{E} + \frac{v^2}{\pi E^2 T} + T \quad (18)$$

Differentiating Eq. (18) with respect to T , remembering that $(S + T)$ is constant, and then equating dE/dT to zero results in the condition

$$\frac{v}{ET} = \sqrt{\pi} \quad (19)$$

Substituting Eq. (19) in (17) results in

$$S/T = 1 + \sqrt{\pi} = 2.77 \quad (20)$$

as the best ratio of plate spacing to plate thickness. Note that the best value of S/T as found above falls within the limits suggested by Ekstrand.

Alternate Forms

Equation (17) may be made more symmetrical by dividing through by T .

$$\frac{S}{T} = \frac{v}{ET} \left(\frac{v}{\pi ET} + 1 \right) \quad (21)$$

Another useful form is

$$\frac{E}{E_{av.}} = \frac{1}{2} \left(1 + \sqrt{1 + \frac{4S}{\pi T}} \right) \quad (22)$$

where $E_{av.} = v/S$.

The form of Eq. (21) suggests that it may be generalized into

$$\frac{S}{T} = \frac{v}{ET} + \sum_{n=0}^{n=\infty} K_n \left(\frac{v}{ET} \right)^n \quad (23)$$

where K_n is to be determined by experiment.

Ekstrand² published some measurements on the sparkover voltage of three capacitors with rounded edges at frequencies of 60 cycles, 700 kc and 1500 kc. Table (1) lists calculated values of maximum gradients on these capacitors as determined by means of Eq. (22). Any modification by corona of effective plate thickness has been neglected.

Frequency-Independent Sparkover

At 60 cycles, the calculated maximum gradients at sparkover do not vary more than about ten percent, with a mean value of 83.8 kv per inch. This value for the sparkover gradient is of the expected order for low frequencies. Only one ca-



the playback equals a personal performance

Jane Pickens popular singing star

AGAIN *aluminum*^{*}
base **AUDIODISCS**

Just as a fine mirror faithfully reflects the

image before it, so does the playback of an Audiodisc recording duplicate the original performance. Each Audiodisc blank has an absolutely smooth surface that does not deteriorate under various storage and operating conditions. The coating of the Audiodisc is homogeneous, uniformly fine in grain, and con-

sistent in density. Sizes from 12 inches in diameter and larger, including master, are available on aluminum* or glass base. Eight and 10 inch diameters on glass base only. Order Audiodiscs from your distributor; or write Audio Devices, Inc., makers of Audiodiscs and Audiopoints, 444 Madison Avenue, New York 22, N.Y.

audiodiscs

they speak for themselves



^{*}Aluminum base limited by WPB to professional uses

**BUT OH BOY,
WHEN THE GROUND
COMES UP AND MEETS YOU**



A hard landing or even the opening jerk of the chute can prove disastrous to electronic tubes unless they are designed and built to take it. Tubes have no knees to bend or body sway to relieve the shock . . . their ability to withstand shock and still maintain design characteristics has to be built into them at the factory.

To be sure that the TUNG-SOL Electronic Tubes used for this and other severe services are able to withstand rough usage, they are given the "Tumble Test". The admirable way they stand

up under it is a tribute to TUNG-SOL engineering and careful production.

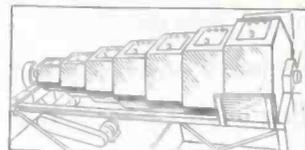
Many of the ruggedness features demanded by the Army and Navy were characteristic of TUNG-SOL Electronic Tubes before the war. Manufacturers and users of electronic equipment and controls will find at TUNG-SOL a complete line of war-proven tubes that will meet every peace-time requirement. Let our engineers think with you when you are planning your post-war products.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

The "Tumble Test" at TUNG-SOL is regularly made on all tubes of new design and tubes picked out at regular intervals from production.

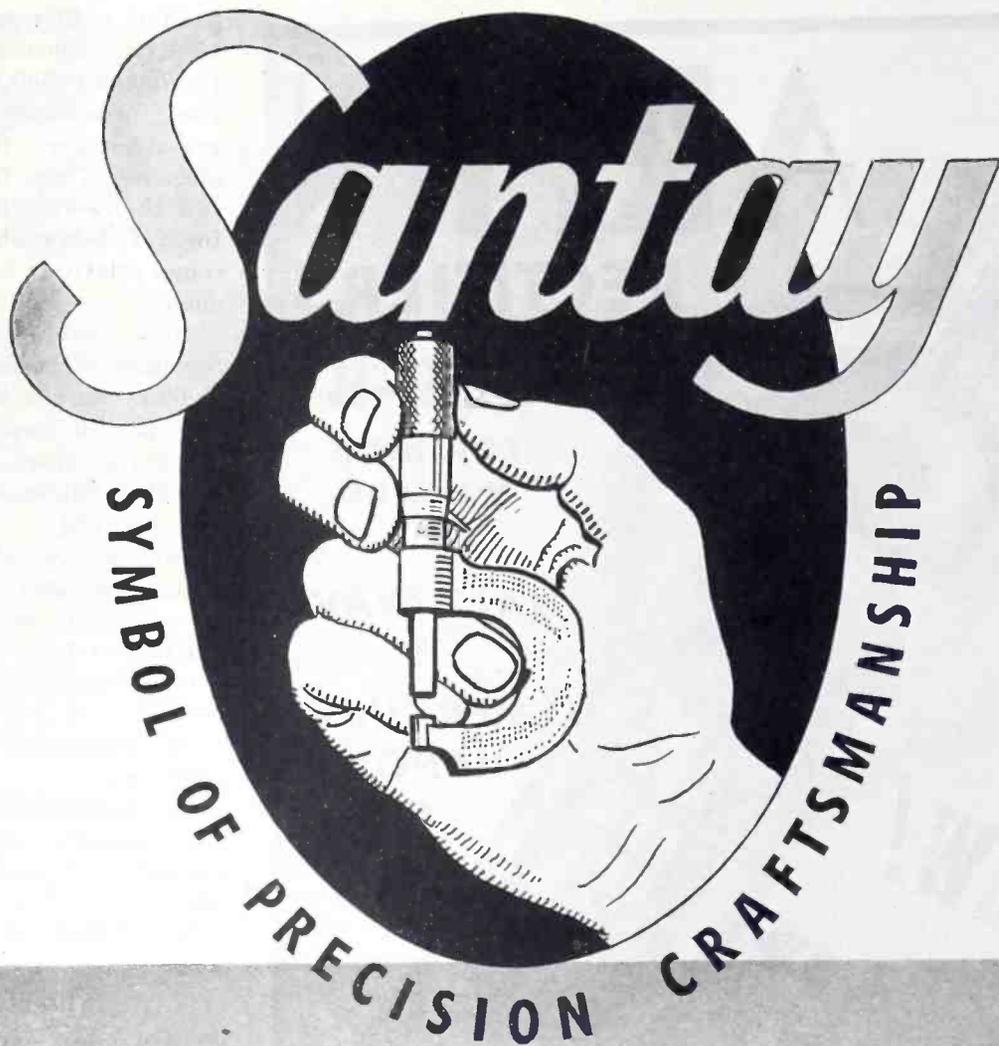


Tubes are put into the various sized angular chambers and tumbled. The larger the chamber the greater the shock. Thus the amount of abuse each tube will withstand is determined, giving our engineers accurate data for design and construction improvements.

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS





SANTAY CORPORATION

FORMERLY SINKO TOOL & MANUFACTURING CO.

351-359 NORTH CRAWFORD AVENUE • CHICAGO 24, ILLINOIS

REPRESENTATIVES: POTTER & DUGAN, INC., 29 WILKESON STREET, BUFFALO 2 • PAUL SEILER,
7779 CORTLAND AVENUE, ELIHOIT 4 • QUEISSER BROS., 108 E. NINTH STREET, INDIANAPOLIS 2

Santay Corporation introduces its new trademark -

"Symbol of Precision Craftsmanship!"

Whenever you see it associated with a thermo-plastic product, metal stamping or electro-mechanical assembly, you'll know that Santay's specialized precision craftsmanship has been and always will be employed to give you the greatest possible satisfaction.



ARPIN RECTIFIERS

869-B

FOR HIGH
VOLTAGE

HALF WAVE

MERCURY
VAPOR

NEW!

1. **DOUBLE** Protection Against Loose Anodes
2. **LARGER,** Heavy-duty Carbon Anode
3. **Withstands High - peak Inverse Voltages with No Arc Back**
4. **Designed for ROUGHER Use — Withstands Vibration**

IDEAL for INDUCTION HEATING

MAXIMUM PEAK INVERSE ANODE VOLTAGE (25-150 cycles) = 20,000 volts.

Maximum Peak Anode Current (25-150 cycles) = 10 amperes

Average Anode Current 2.5 amperes (In-phase filament excitation)

Typical Conditions in A Single Phase, Full-Wave Circuit (2 tubes)

A.C. Input voltage, 7070 (RMS per tube)—D.C. Output voltage, 6360

Maximum D.C. Load current—5 amperes

ARPIN 575-A MERCURY VAPOR RECTIFIER

Two tubes for full-wave rectification in single phase circuits deliver 5000 volts D.C. at 3 amps. with good regulation. Filament 5 volts, 10 amps. Peak plate current 6 amps. Peak inverse voltage 15,000 volts. Fully guaranteed.

**Write Today for the
NEW ARPIN CATALOG**

ARPIN MANUFACTURING CO. 422 Alden Street
Orange, New Jersey

capacitor, with a ratio of S/T equal to 1.705, approximates this value for 700 and 1500 kc. The other two give breakdown gradients progressively lower for increasing frequencies. These facts seem to indicate that a critical value may exist for S/T , below which sparkover becomes relatively independent of frequency.

Note that the sparkover performance of these three capacitors at 60 cycles can be predicted from Eq. (22), at least to common engineering accuracy. For use in testing this relationship further, Eqs. (21) and (22) are plotted in Fig. 1.

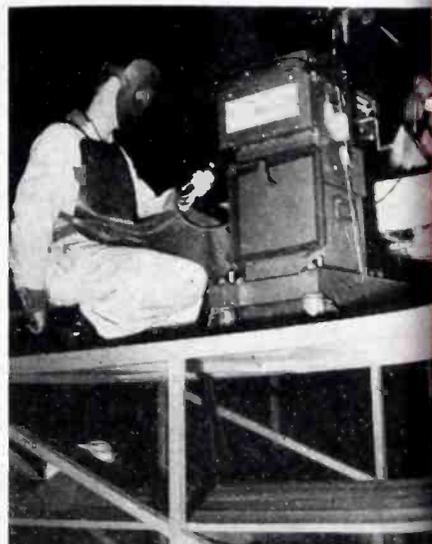
Implications of the foregoing analysis suggest several leads for experimental verification or qualification, as follows:

- (a) Verification of the best value for S/T .
- (b) Evaluation of K_1 in Eq. (23).
- (c) Determination of the relation between corona onset and the radius of curvature of the plate edge.
- (d) Effect of increasing frequency.

REFERENCES

- (1) Peek, F. W., "Dielectric Phenomena in High Voltage Engineering," third edition, McGraw-Hill Book Co., 1929, pp. 30-31.
- (2) Ekstrand, P. A., Radio-Frequency Sparkover in Air, *Proc. I. R. E.*, 28, No. 6, June, 1940, p. 262-266.
- (3) Same as (1), chapters 4 and 5.
- (4) Darrow, K. K., "Electrical Phenomena in Gases," Williams and Wilkins Co., 1932, chapter 9.
- (5) Ollendorf, R. R., and Pohlhausen, E., "Theory of Functions," Technological Press, 1942, p. 188-140.

X-RAY CLIPPER SPARS



To insure safety in flight, duralumin spars of the extensive wing section of a Clipper are x-rayed for possible hidden flaws that escape visual inspection

Centralab

CERAMIC CAPACITORS

for HIGH VOLTAGE

These capacitors are engineered by Centralab for special applications . . . accumulative capacities ranging from 2MMF to 20MMF in zero temperature coefficient . . . to 4MMF to 40MMF in maximum negative (N750 PPM) temperature coefficient.

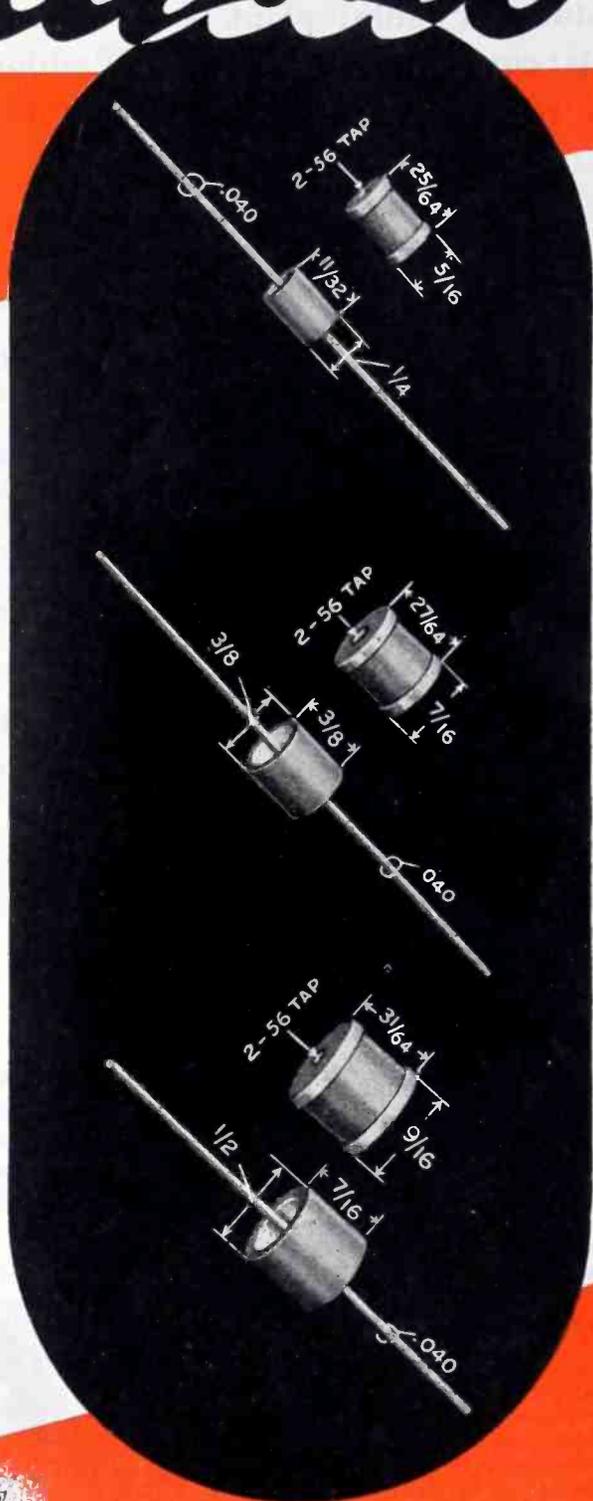
Individually the capacity ranges are as follows:

- | | |
|-----|--|
| 855 | 2MMF to 5MMF in zero T. C.
4MMF to 10MMF in N750 |
| 854 | 5MMF to 10MMF in zero T. C.
10MMF to 20MMF in N750 |
| 853 | 10MMF to 20MMF in zero T. C.
20MMF to 40MMF in N750 |

Working voltages from 8,000 to 10,000 D.C. Energy dissipation up to 2 KVA with 15°C rise.

End lead or axial screw terminals available.

Send for Bulletin No. 814.



Producers of Variable Resistors • Selector Switches
• Ceramic Capacitors, Fixed and Variable •
Steatite Insulators.

Centralab

Division of GLOBE-UNION INC., Milwaukee

NEWS OF THE INDUSTRY

Television possibilities; postwar technical education; Coast-Guard radio; plant broadcasting; relay experiments; conventions; notes from Washington on production, station sales, and communications fellowships

Toward a Standard Television Picture Tube

ONE STANDARD flat-faced 10-in television picture tube may result from activities of Corning Glass Co., makers of the envelopes for practically all cathode-ray tubes. Heretofore it has been impossible to use automatic equipment on production of envelopes because of the wide range of sizes, shapes, and compositions. Hand-made techniques have been responsible for high prices.

A special new department at

Corning will combine the development of envelopes with development of machinery for large-quantity production. Having surveyed the field, the company feels that standardization is quite feasible, with particular interest having been shown in the 10-in. size. Resulting picture will be six by eight, a new size for American receivers, though used in British sets. Demand is estimated at one million tubes a year.

Costs for Television Broadcasting Equipment

CONSIDERING THAT 480 of the 917 broadcasting stations in the U. S. have invested less than \$30,000 in equipment, Leonard F. Cramer, executive vice president of Allen B. DuMont Laboratories believes the average prospective television broadcaster of the future will be thinking in terms of station costs near \$250,000. Speaking recently to the television seminar of the Radio Executives Club of New York he presented the following figures based on pre-war costs:

Studio Equipment and Transmitter	
2 Iconoscope cameras mounted on push dollies	\$23,000
Studio Control Desk	
Electrically controlled camera dolly	2,500
2 Special film projectors	12,000
2 Iconoscope film pickup cameras	6,000
Master control board	35,000
Transmitter, 25 kw video—12.5 kw audio, with control console	65,000
Antenna	10,000
	\$153,500
Field Pickup Equipment	
2 Field pickup cameras with controls	\$24,000
Relay transmitter	8,000
Relay receiver	2,000
Field audio equipment	1,500
Truck with generator and antenna	5,000
	\$40,500
Installation, Sound, Lighting	
Studio installation	\$15,000
Soundproofing, elec. wiring, etc.	25,000

Studio lighting, sound equipment, etc.	10,000
Fireproofing film studio	1,500
Equipment spares and test instruments	13,000
	\$64,500
TOTAL	\$258,500

Middle East

MARVIN CAMRAS, right, inventor of the magnetic wire recorder developed at Armour Research Foundation, demonstrates its features for Louis P. Birk, director of public information for the United Nations



Relief and Rehabilitation Administration. The unit is to be taken to the Middle East for use in refugee camps. Health and hygiene, friendly relations, and public information and instruction will be featured.

Rochester Meeting Program

TECHNICAL PAPERS scheduled to be presented at the Rochester War Conference on Nov. 13 and include the following subjects:

- The Reactance Theorem for a Resonance, by W. R. MacLean, Polytechnic Inst. Brooklyn.
- A Resonant Cavity Method for Measuring Dielectric Properties at U-H-F, by C. Works, T. W. Dakin, F. G. Boggs, Westinghouse Elec. & Mfg. Co.
- The RCA Laboratories at Princeton, E. W. Engstrom, Radio Corp. of America.
- Low Frequency Compensation of Multistage Video Amplifiers, by M. J. Larson.
- Trends in Receiving Tube Design and Application, by L. R. Martin, Radio Corp. of America.
- Standardization of Capacitors for Civil Equipment, by J. I. Cornell, Solar Corp.
- Report of RMA Director of Engineering, W. R. G. Baker.
- The Organization of Research in the Radio Industry after the War, by Rufus Machurin, Massachusetts Inst. of Technology.
- Electronic Tube Trends, by R. M. W. Sylvania Electric Products Inc.
- Silicone Products of Interest to the Radio Industry, by Shaller L. Bass.
- T. A. Kauppli, Dow Corning Corp.
- Designing Thoriated Tungsten Cathodes, by H. J. Dailey, Westinghouse Elec. & Mfg. Co.

Salvage of Electronic Products

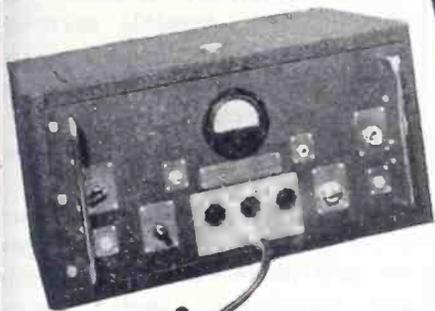
TO SALVAGE AND RECLAIM every type of electronic product used by the Navy, six material and redistribution centers are being established on the Pacific Coast. Obsolete, battle-worn, and surplus equipment is to be reclaimed, and redistributed as replacements, spare parts or scrap. Centers will be located in Irvington, Stockton, Torrance, and San Francisco, Calif., and Salem, Ore.

Walkie-talkies are the particular consideration of recent instruction sent by the Signal Corps of the Army to signal depots in the U. S. and abroad. Older reradiating models are dismantled and stripped of 85 parts, 27 of which can be re-used in or with other Signal Corps equipment. Even the quartz crystals are turned over to a field grinding unit for further use. Resistors and capacitors with pigtail less than an inch are reluctantly scrapped.

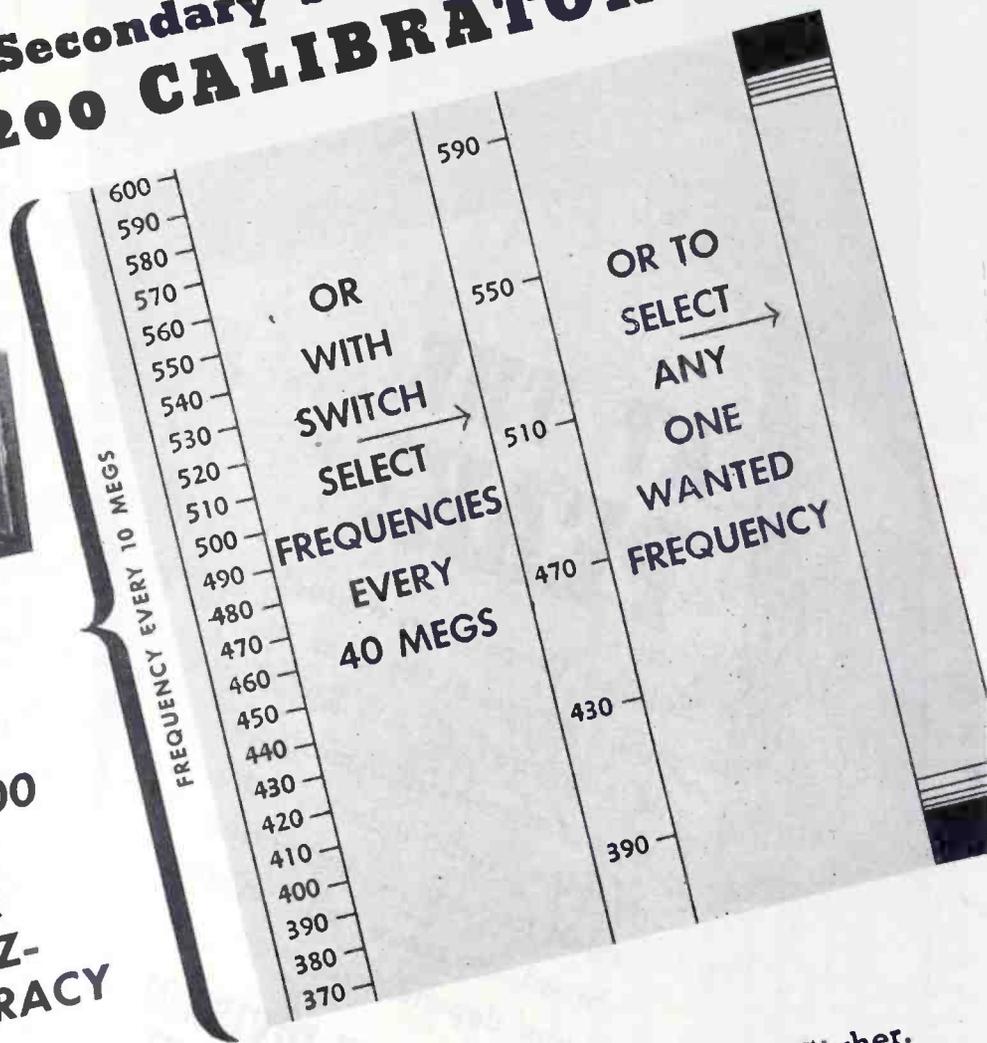
Elections in RMA

RECENTLY ANNOUNCED department directors of RMA include: by-law and organization, Leslie F. Muter; engineering, W. R. G. Baker; industry reconversion, A. W. Wells; NEMA tube classification, W. R. G. Baker; RTPB television reporting

the **NEW**, Secondary Standard **LAVOIE C-200 CALIBRATOR**



**WILL PRODUCE
HARMONICS
FROM 10 TO 2000
MEGACYCLES
AND HIGHER
WITH QUARTZ-
CRYSTAL ACCURACY**



The **LAVOIE C-200 CALIBRATOR**...

1. Produces only harmonic frequencies of 10 megas up to 2000 megas or higher.
2. By means of a switch cuts out 10's and produces only 30's on the megacycle frequency range.
3. By means of the Identifier, selects any one frequency for purposes of identification.
4. Is equipped with a detector and amplifier on the panel for use with calibrating signal generators, etc., etc.

Write for detailed information.

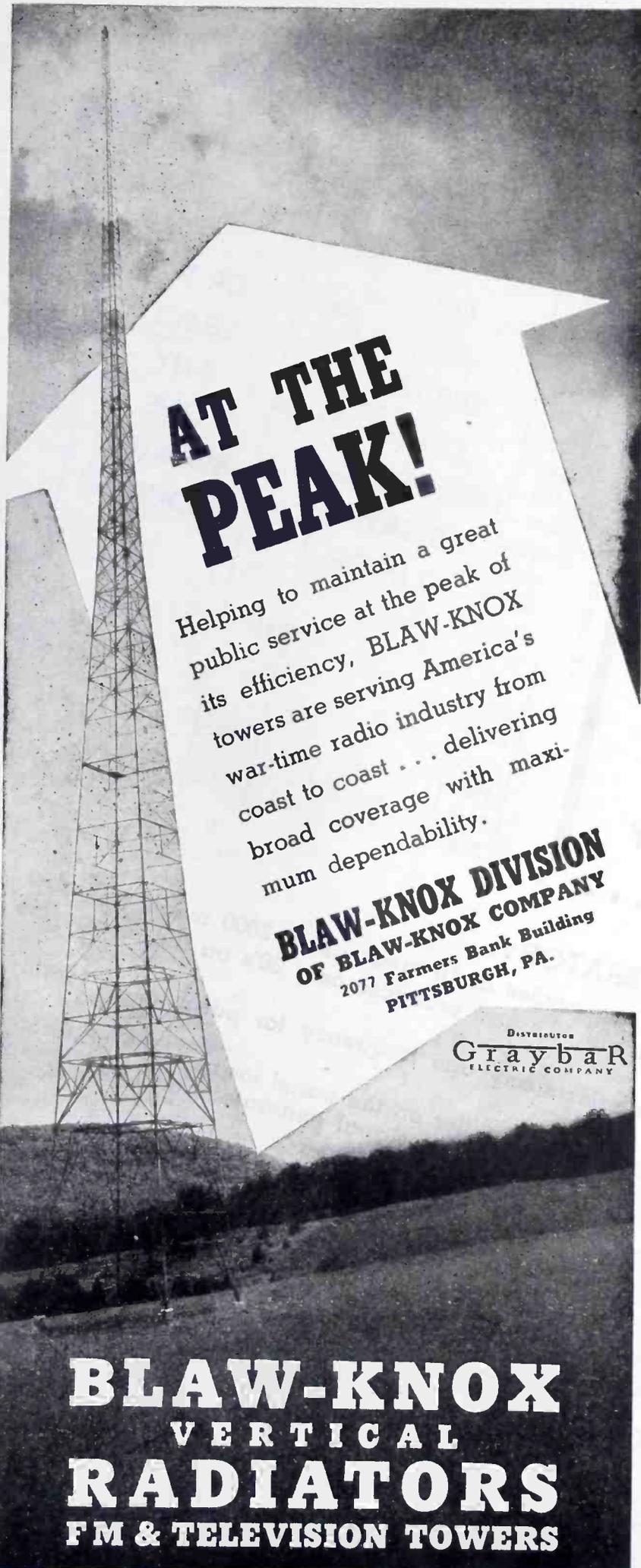


Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.

Specialists in the Development of UHF Equipment



AT THE PEAK!

Helping to maintain a great public service at the peak of its efficiency, BLAW-KNOX towers are serving America's war-time radio industry from coast to coast . . . delivering broad coverage with maximum dependability.

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BLAW-KNOX
VERTICAL
RADIATORS
FM & TELEVISION TOWERS

Ray H. Manson. In the transmitter division, the following section chairmen have been listed: radio transmitter tubes, H. C. Vance; broadcast transmitters, C. W. Miller; emergency service communication, F. A. Gunther; aviation equipment, J. W. Hammond; marine equipment, F. R. McMullen; and piezoelectric quartz crystals, G. E. Wright.

Other section chairmen are school sound systems, amplifier and sound equipment division, Laurence A. King; crystals, parts division, F. D. Bliley; insulations (tubing, tape, sleeving, varnishes, and sealings), parts division, John W. Apgar; metal stampings and metal specialties, parts division, W. W. Barry; plastics and molded parts, parts division, R. R. Titus; speakers and parts (including headset and magnets), parts division, Henry C. Forster.

Police Lineup by Television

A NEW WEAPON for the apprehension of criminals after the war may well be the telecast police lineup by which a central station might familiarize police over a large area with the lawbreakers under current custody. Speaking before a meeting of the New York State Association of Chiefs of Police, Commissioner Edward J. Hickey of the Connecticut State Police hoped such facilities might be available to combat a possible post-war crime wave.

In another talk at the same conference, Frank J. Wilson, chief of the U. S. Secret Service suggested that similar facilities could be used to make the public familiar with the particular tricks of confidence men thought to be operating in a certain area, to dramatize the conditions leading to juvenile delinquency, and to generally aid in law enforcement.

Large-Screen Television Prospects

BASED ON USE of the Skiatron and supersonic light relays which make it possible to project a great number of picture elements simultaneously, Scophony Corp. of America expects to merchandise a postwar home television receiver with a flat, projected picture 18 x 14½ in. for a price somewhere in the vicinity of \$200.

A similar model was introduced

HIPERSIL* CORES

Reduce weight

40%

HIPERSIL CORES

COMBINE THESE ADVANTAGES:

- 30% to 50% lighter weight
- 33 $\frac{1}{3}$ % more flux-carrying capacity
- Very high, high-density permeability
- High, low-density permeability
- High incremental permeability
- Very low losses in direction of rolling
- Space factor as high as 95% . . . thin glass films insulate adjacent laminations.



Westinghouse
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

HIPERSIL

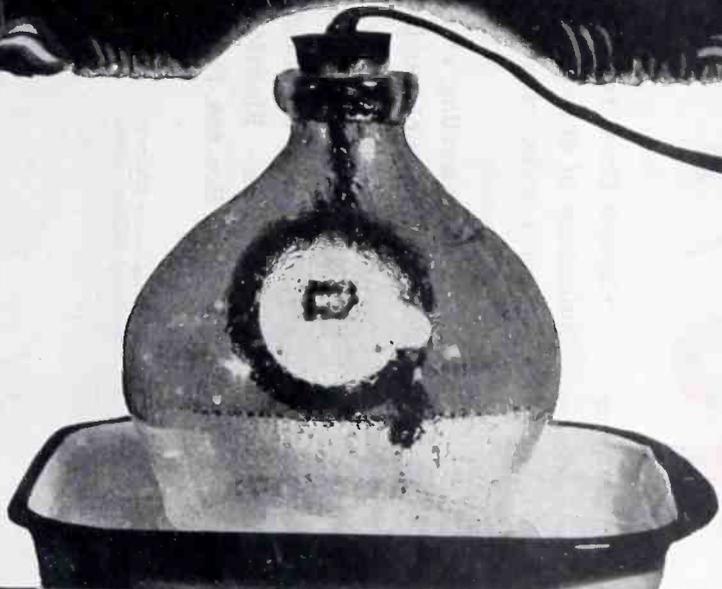
This aircraft transformer is tangible proof of the weight and space savings made by Hipersil Cores.

With them, engineers cut the weight of the transformer to 8 ounces, approximately 40% less than the nearest competitive item of the same output. The unit has a low temperature rise of 30° which permits operation over all ambients from minus 65° to plus 70° C at all altitudes up to 50,000 feet.

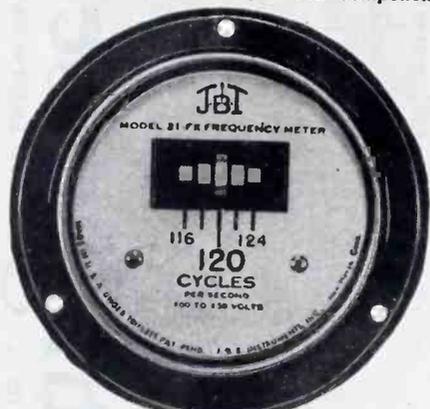
Hipersil Cores release engineers from the limitations of ordinary silicon steel. Hipersil affords a wider range of linear response . . . approximately $\frac{1}{3}$ greater straight-line response for winding and core section. Construction is simplified because there are no "tissue-thin" laminations to stack . . . only 2 or 4 pieces to handle. Learn the facts about Hipersil. Write for Booklet B-3223. Address: Westinghouse Electric & Manufacturing Co., P. O. Box 868, Pittsburgh 30, Pa. J-70433

*Registered Trade-Mark Westinghouse Electric & Mfg. Co., for High PERmeability SILicon steel.

Jungle-Proof FREQUENCY METERS



Jungle Conditions—One of the laboratory tests simulating field use is a minimum run of 120 hours at 120° F, 95 RH. Component parts have previously been tested at 180° F.



Model 21 FX-2 1/2 inch instrument with plastic case for use where weight and space are important.

If you had to work in a jungle, the stifling heat and humidity approaching the saturation point might get you . . . but not J-B-T Frequency Meters. These meters can take it . . . and do . . . heat and moisture notwithstanding.

Suspended in open bottom bell jars over steaming water, J-B-T Frequency Meters consistently indicate

correct frequency or speed although dripping wet. This is so because in J-B-T simplified construction, the only moving part is the reed, which *throws off* moisture as it operates, and because all component parts are protected by the most advanced moisture-resistant finishes.

Jungle-proofing is not the only assurance of reliability. J-B-T Vibrating Reed Frequency Meters are also unaffected by mechanical shocks, voltage drop, change in wave form or external magnetic fields.



Send for illustrated bulletin VF-43 including VF 43-1A on 400 cycle meters and VF 43-1B on the new compact 2 1/2 inch meters.

(Manufactured under Triplett Patents and/or Patents Pending)



J-B-T INSTRUMENTS, INC.

431 CHAPEL STREET • NEW HAVEN 8, CONNECTICUT

in England just before the war priced at £70 or approximately \$310 at prewar sterling rates. The low price will depend upon large-scale production, according to Arthur Levey, president of the company who addressed a recent session of the television seminar of Radio Executives Club in New York recently. A larger model which included the same electronic gear, but a modification of the optical system, produced a picture 24 x 20 in.

Among company developments some of which are currently connected with secret projects, is a scrambling device which makes it possible for television programs to be directed to special, authorized subscribers, while television projection for theaters is anticipated through the company's connection with Paramount Pictures. Projected pictures 18 ft wide were used successfully in two London theaters before the war.

Postwar Educational Trend

ACCORDING to the G.I. Bill of Rights every eligible veteran will have about \$1,000, exclusive of his bonus to spend studying for a better peacetime job. In 1939 there were 125 students in technical and trade schools to each 100 in regular college. Feeling that many of the veterans will prefer trade school preparation to courses in history, literature, or foreign languages, a group of technical schools is forming a trade association, headed by Dr. J. S. Noffsinger, Washington, D. C., to raise standards of ethics, improve courses, and bring technical schools in closer touch with industry. Individual schools will be inspected, revised, and placed on an approved list which will give their graduates greater prestige among employers.

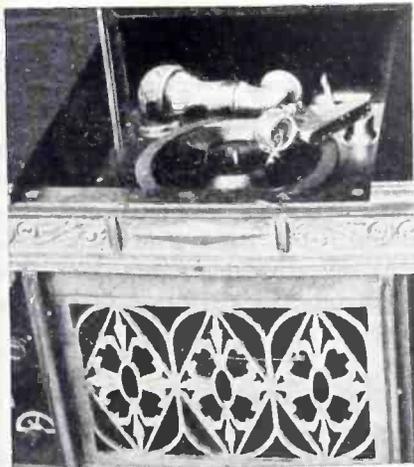
Coast-Guard Radio

CELEBRATING ITS 154th anniversary, the U. S. Coast Guard points out that its history includes pioneer work on ship and aeronautical radio. The Revenue Cutter Service, as the Coast Guard was called then, first used wireless telegraphy in 1903 for ship-to-shore communication. Credit for establishment of the standard 500-kc distress fre-

THERE IS NO SUBSTITUTE FOR EXPERIENCE



In 1915 Magnavox engineers produced this "daddy" of all loud speakers—the horn-type electro-dynamic speaker. Today the electro-dynamic loud speaker is the "voice" of modern sound reproduction in radio, sound motion pictures and all other kindred fields.



In 1922 Magnavox engineers developed this historic instrument—the first amplified radio-phonograph. As the forerunner of all present day radio-phonograph combinations, it marked an important advance in the development of sound reproduction.

THESE EXAMPLES serve to remind us how closely the history of radio is interwoven with that of the Magnavox Company.

In 1911 the electro-dynamic reproducer, developed by this company's engineers, completely revolutionized the art of sound reproduction. The same principle is used in all radios today.

Magnavox for years has been not only the world's largest supplier of loud speakers, but also one of the largest producers of electrolytic condensers. This experience dates from the original "Mershon" to the current Magnavox type.

The experimental work that built the Magnavox reputation is constantly perpetuated—now intensified and broadened by highly diversified war work. Magnavox is your logical source for components and for cooperation in your future projects. The Magnavox Company, Fort Wayne 4, Indiana.

Magnavox

Loud Speakers • Capacitors • Solenoids
Communication and Electronic Equipment



Another important step forward was achieved with this first single-dial radio produced by Magnavox in 1923. Its importance at the time is appreciated when we remember that all previous radio sets required the use of three dials for tuning in a station.



The cone type of electro-dynamic speaker was introduced by Magnavox engineers in 1927. It was the prototype of all electro-dynamic speakers in use today, recognized throughout the world as the most efficient means for the electrical reproduction of sound.

500,000,000 to ONE

0.00002 TO 10,000 VOLTS

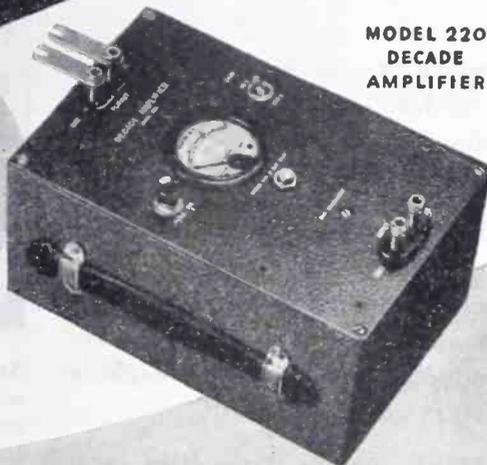


MODEL 300

ELECTRONIC VOLTMETER



MODEL 402
MULTIPLIER



MODEL 220
DECADE
AMPLIFIER

This enormous range of voltages—five hundred million to one—is accurately covered by our Model 300 Electronic Voltmeter and some of the accessories shown above. Frequency range 10 to 150,000 cycles. Accuracy 2% over most of the range. AC operation. Five decade ranges with logarithmic scale make readings especially easy. Uniform decibel scale also provided. May also be used as a highly stable amplifier, 70 DB gain, flat to 150,000 cycles.



BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

quency and for the use of the telegraph "sparks" in connection with operators belongs to this service. Let us see when the Revenue Cutter Service and the Life Saving Service have been merged to form the Coast Guard, radio was first used for aircraft communication and flight guidance. Detailed pioneering work involved the rotatable electrostatically-shielded d-f antenna and cathode-ray direction indicating instruments.

Radio Relay Allocation

HITHERTO COMMERCIAL frequencies have been allocated to American Tel. & Tel. Co. for experimentation on a radio relay system between New York and Boston. Facilities will be suitable for facsimile, and television broadcast relay as well as telegraph and telephone communication.

Two Class 2, 10-watt stations are provided for in the present authorization, while seven fully automatic relay stations are planned for the intervening space. Cost is estimated at \$1,000,000.

News by Plant Broadcast

MORE THAN 5,000,000 American workers have been kept up to date on recent military developments through sound systems installed in war plants from coast to coast. Stromberg-Carlson Company has conducted a survey among users of such apparatus.

Keeping the workers continually apprised as to the true situation has made it possible, at the same time, to utilize the driving power of the worker's reaction and to circumvent gossip.

Most of the plants reported casting their communication systems in this role had previously used them mainly for paging officials, broadcasting speeches, and in general utilizing the facilities in the manner of talking bulletin boards.

CONVENTIONS TO COME

Oct. 2-5. Forty-Ninth Annual meeting, Boston, Mass. INTERNATIONAL MUNICIPAL SIGNAL ASSOCIATION, Irwin Shulsinger, secretary, 8 East 41 St., New York, N. Y.

Oct. 5-7. NATIONAL ELECTRONICS CONFERENCE, Chicago, Ill., B. Dud-

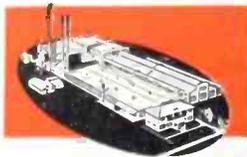


That's a *TRICK*, Mr. Jones ...and we know it!

PLASTIC MATERIALS, you know, vary considerably. Not only in regard to physical properties *after* molding, but in regard to molding behavior as well. In other words, your plastic part has to be designed in full recognition of your material. That's why we say that the selection of material is another job for your custom molder!

But Kurz-Kasch does more than team up these two functions. In growing up with the plastics industry, we've found

Why Kurz-Kasch for Plastics? Kurz-Kasch offers a 28-year-old reputation for thoroughly engineered, quality production. • One of the largest, best-equipped exclusive custom molding plants in the country—75,000 square feet of floor space with 125 compression and transfer presses of all sizes.



it wise to insist that experts on mold-making, molding and finishing add their opinions during the planning stage. This way, you can rest assured that your job will be estimated right—produced right—and delivered right on schedule.

This service is available from the moment you first wonder if plastics will fit into your program. In fact, that's the time to get the most out of it. We urge you to feel free to use it—now!

Complete mold-making and finishing facilities • Extensive production sequences of radio-frequency preheating equipment, with full experience in their use. Completely equipped shop for production of inserts • For satisfaction in plastics, key these facilities into your production line.

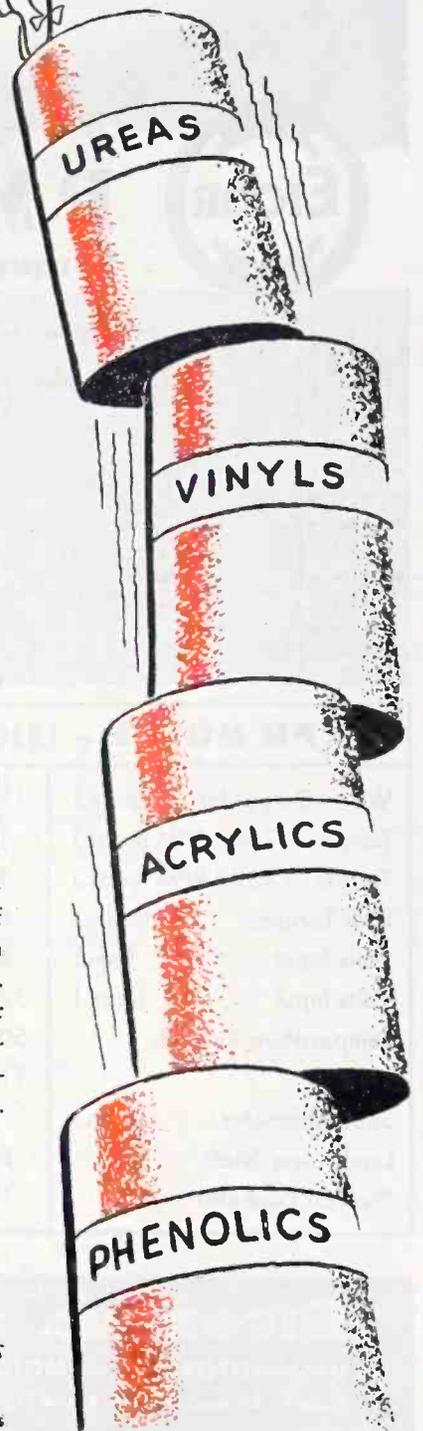
BUY BONDS! ALL YOU CAN — WHENEVER YOU CAN

KURZ-KASCH

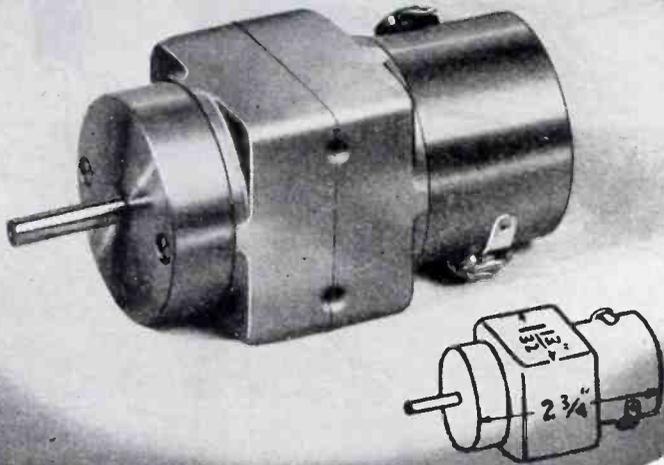
For over 25 years Planners and Molders in Plastics

Kurz-Kasch, Inc., 1425 South Broadway, Dayton 1, Ohio

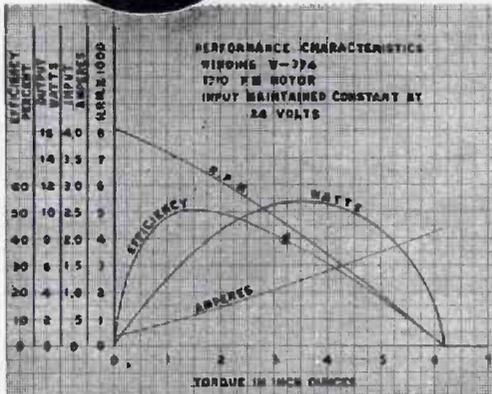
Branch Sales Offices: New York • Chicago • Detroit • Indianapolis • Los Angeles • Dallas
St. Louis • Toronto, Canada. Export Offices: 89 Broad Street, New York City



MOTOR DATA No. 124



PM MOTOR Torque 3.5 in. oz. at 4500 RPM



PM MOTOR - 1310

Watts Output Int. (max.)	11
Torque at 7000 RPM (in. oz.)	1
Torque at 4500 RPM (in. oz.)	3.5
Lock Torque (in. oz.)	6
Volts Input (min.)	5
Volts Input (max.)	32
Temperature Rise Int.	50°C
Weight	11 oz.
Shaft Diameter (max.)	.250"
Length less Shaft	2 3/4"
Overall Diameter	1 13/32"

Unique in design and construction, this permanent magnet field motor has been selected for many applications having critical space and weight factors. Wound as a shunt motor, its output characteristics are adaptable for a wide variety of power requirements.

FEATURES

ELECTRICAL

- Alnico field magnets
- No field losses
- Low starting current
- Reversible with change of polarity
- Low RF interference
- Armature windings varnish impregnated and baked

MECHANICAL

- Completely enclosed
- Mounting in any position
- Aluminum end brackets
- Laminated pole pieces
- Stainless steel shaft
- Rotation on ball bearings
- Commutator mica insulated

EICOR INC. 1501 W. Congress St., Chicago, U. S. A.

DYNAMOTORS • D. C. MOTORS • POWER PLANTS • CONVERTERS

Export: Ad Auriema, 89 Broad St., New York, U. S. A. Cable: Auriema, New York

ley, secretary, 520 N. Michigan Ave., Chicago, Ill.

Oct. 12-14. Fall Meeting, Buffalo N. Y. ELECTROCHEMICAL SOCIETY Colin G. Fink, secretary, Columbia University, New York 27, N. Y.

Oct. 16-18. Fifty-Sixth Semi-Annual Fall Conference, New York N. Y. SOCIETY OF MOTION PICTURE ENGINEERS. W. C. Kunzmann, vice president, Hotel Pennsylvania, New York, N. Y.

Oct. 16-19. Twenty-Fifth Annual Meeting, Cleveland, Ohio. AMERICAN WELDING SOCIETY, M. M. Kelly, secretary, 33 West 39 St., New York 18, N. Y.

Oct. 19-21. Electronic Parts and Equipment Industry Conference, Chicago, Ill. PARTS DIV., RMA; ASSOCIATION OF ELECTRONIC PARTS AND EQUIPMENT MANUFACTURERS - EASTERN DIV., SALES MANAGERS CLUB; and NATIONAL ELECTRONICS DISTRIBUTORS ASSOCIATION; H. W. Clough, chairman, PO Box 5070-A, Chicago 80, Ill.

Oct. 20. Annual Meeting, New York, N. Y. ENGINEERS COUNCIL FOR PROFESSIONAL DEVELOPMENT, S. L. Tyler, secretary, 29 West 39 St., New York 18, N. Y.

Oct. 20-21. Twenty-Ninth Annual Meeting, New York, N. Y. OPTICAL SOCIETY OF AMERICA, Arthur C. Hardy, secretary, Massachusetts Institute of Technology, Cambridge 39, Mass.

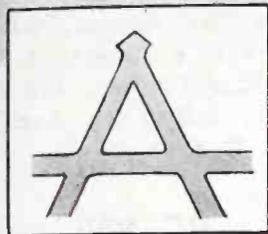
Nov. 2-3. National Time and Motion Study Clinic, Chicago, Ill. INDUSTRIAL MANAGEMENT SOCIETY, C. S. Becker, vice president, 205 West Wacker Drive, Chicago 6, Ill.

Nov. 9-10. Fall Meeting, Dayton, Ohio. INSTITUTE OF THE AERONAUTICAL SCIENCES, Robert R. Dexter, secretary, 1505 RCA Bldg. West, Rockefeller Center, New York 20, N. Y.

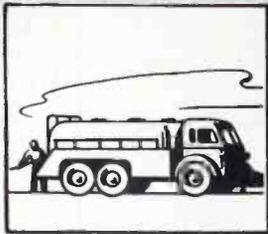
Nov. 13-14. Rochester Fall Meeting & War Radio Conference, Rochester, N. Y. ROCHESTER FALL MEETING COMMITTEE, Virgil M. Graham, chairman, PO Box 750, Williamsport, Pa.

Nov. 13-14. Annual Fall Convention, New York, N. Y. SOCIETY OF THE

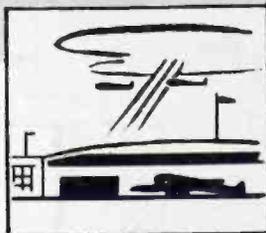
Your Airport may have all of these



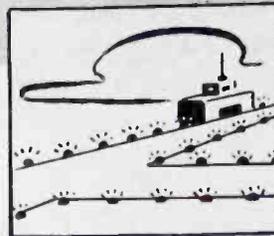
RUNWAYS



SERVICE



HANGARS



LIGHTS

But it still is not a modern airport serving your community to best advantage, if it does not have radio facilities ➔



Essentials of a modern airport, in the order of their importance, might be listed this way:

- | | |
|--|--|
| 1. Adequate all-weather runways. | 6. <u>Radio navigational facilities.</u> |
| 2. Sufficient service for normal requirements. | 7. <u>Weather information.</u> |
| 3. Hangar space. | 8. Terminal facilities including restaurants, taxi service, etc. |
| 4. Lights. | 9. Accessible location. |
| 5. <u>Control tower.</u> | 10. Safe approaches from all directions. |

and—an able, adequately paid airport manager who can make the fullest use of his facilities in the interests of the public, flyers and the airlines.

Our job—that of RADIO RECEPTOR—is the provision of radio facilities for navigation—for traffic control—for communication. Chances are RADIO RECEPTOR ranges—supplied to the CAA—may guide the planes to your airport. Let RADIO RECEPTOR traffic control equipment continue the job and bring them down to the runways and up to the gates.

Competent counsel on airport traffic control radio now available—equipment supplied when conditions permit. *Plan now—purchase later.*

Send for our informative 16-page, 8 x 11 publication

“HIGHWAYS OF THE AIR”

which discusses radio navigation and traffic control in all its phases, military and civilian—past, present and future. Free to those writing on their letterhead.

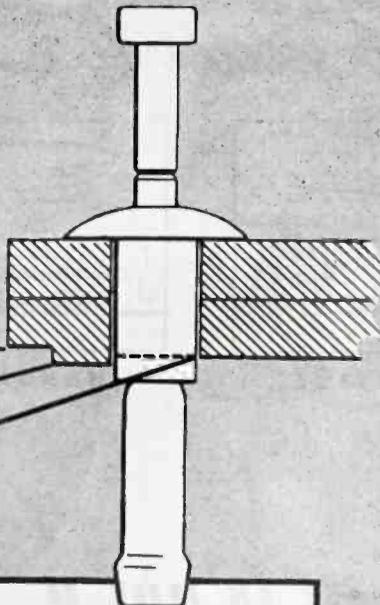
RADIO RECEPTOR COMPANY, INC.
251 WEST 19th STREET NEW YORK 11, N. Y.

Airway and Airport Radio Equipment • Communications Equipment • Industrial Electronics • Electronic Power Generators

SINCE 1922 IN RADIO AND ELECTRONICS

Look! . . . Material thickness may vary a sixteenth of an inch—lots for a blind rivet—and still give you a perfect job.

MINIMUM
MAXIMUM
NOMINAL



CHERRY RIVETS GIVE GENEROUS TOLERANCES IN GRIP LENGTH!

Don't hesitate to use blind rivets just because the materials used may vary slightly in thickness in different areas. Use Cherry Rivets. As long as you stay within the generous tolerances specified, you'll get a good finished job.



The Cherry Rivet head (patented): (1) slips easily into the tool, (2) provides a positive grip, (3) keeps the rivet parts assembled as a unit.



CHERRY RIVETS, THEIR MANUFACTURE AND APPLICATION ARE COVERED BY U.S. PATENTS ISSUED AND PENDING

Cherry Rivet

Company
LOS ANGELES, CALIFORNIA

Here's a handbook on Cherry Rivets. Read it and find out how tough jobs can be made easy with Cherrys. Write for Handbook A-43 to Dept. A-120, Cherry Rivet Company, 231 Winston Street, Los Angeles 13, Calif.

PLASTICS INDUSTRY, C. S. Shaker, meeting chairman, DuPont Chemical Co., 30 Rockefeller Plaza, New York 20, N. Y.

Dec. 7-8, First Annual Conference, New York, N. Y. TELEVISION BROADCASTERS ASSOCIATION, Will Baltimore, secretary, 500 Fifth Ave., New York 18, N. Y.

D.C. BIAS

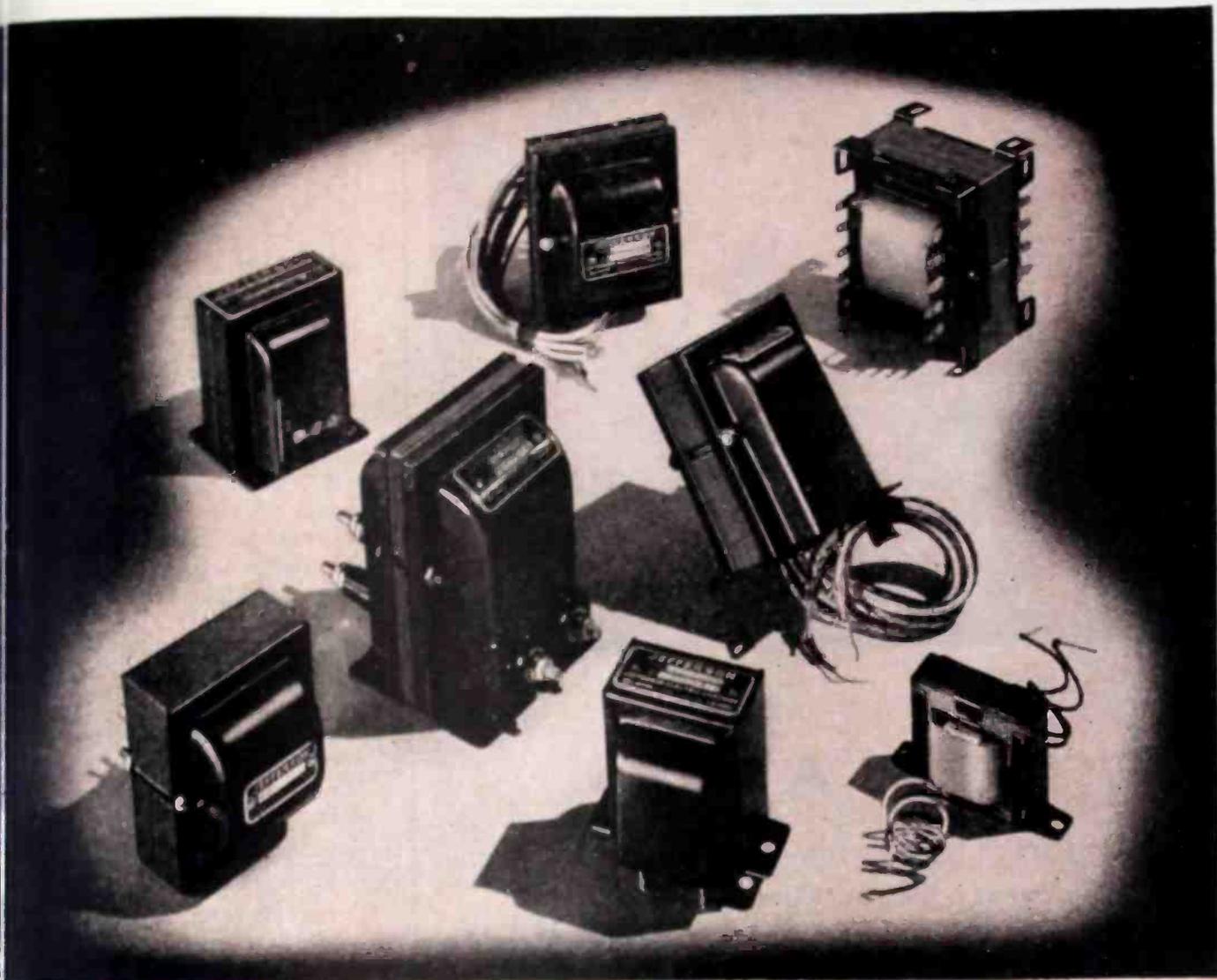
CIVILIAN RADIO. Production of civilian radios will be resumed after Germany surrenders, and not before such time, the Radio Industry Advisory Committee was told by leading WPB officials at a recent meeting in Washington.

These officials told the committee that the radio-radar production program for 1944 must continue upward through December and about 16.4 percent above the July output rate. Army and Navy officials concurred in this estimate of over-all increase during the remainder of the year.

FORESTRY OPERATION. With several provisos, FCC has amended its rule so a licensed operator who is the holder of a radiotelephone or radiotelegraph first or second class license may be on duty as the operator of one or more forestry stations licensed in the name of the same person, municipality, or state at any location within the reliable daytime communication range of each such station in lieu of the transmitter locations or control point(s) during actual operation of the transmitting apparatus employing telephony.

UPHILL PRODUCTION. The forthcoming months will be more critical than any period previously faced by the electronic industry, and as a consequence the industry and WPB must effect the maximum cooperation on all problems, Ray C. Ellis, director of WPB's radio and radar division, recently advised the Industrial Instrument Industry Advisory Committee.

Reasons for the need of closer cooperation include problems of cancellation of contracts, reconversion, and labor which must be anticipated, he said. Commenting on the overall electronic industry production rate, Mr. Ellis pointed out that July, 1944, showed an increase of



Quality in Quantity

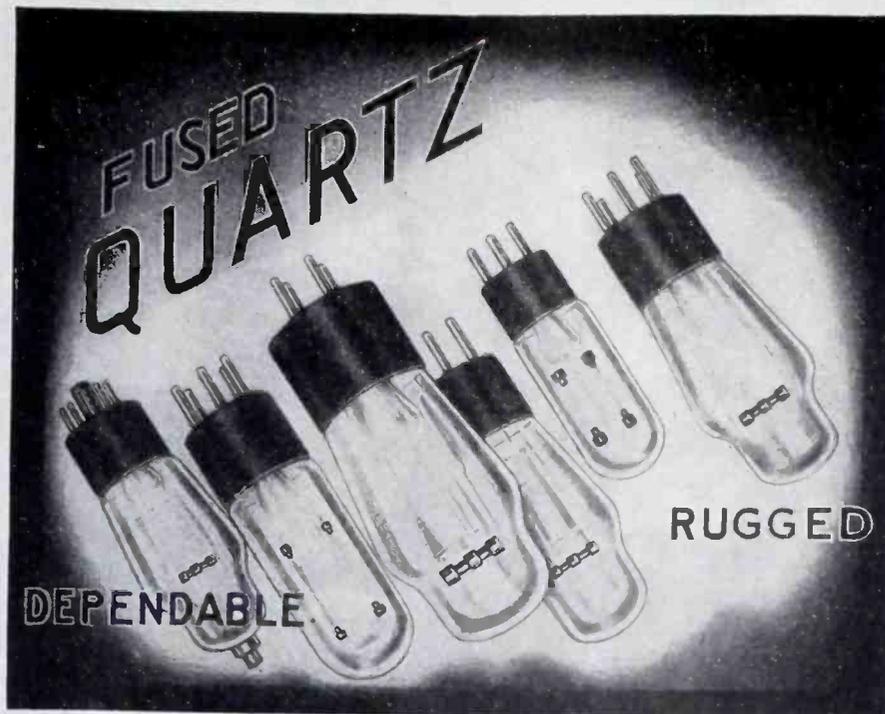
WITH COMPLETE control of the design, selection of all materials, and methods of manufacture of all parts to the final assembly, inspection and delivery,—Jefferson Electric Transformers are laboratory correct whether required in small lots or hundreds of thousands.

War-time demands have further emphasized the ability to maintain high uniform standards of quality on a mass production basis. Under the stimulus of War effort, advanced types of

machinery, and improved manufacturing technique, you can count on still better Jefferson Electric products for your post-war needs. Consulting now with Jefferson Electric transformer engineering specialists will save time for you later . . . JEFFERSON ELECTRIC COMPANY, Bellwood (Suburb of Chicago), Illinois. In Canada: Canadian Jefferson Electric Company, Limited, 384 Pape Avenue, Toronto, Ontario.



TRANSFORMERS



INSULATORS

are a "Main factor" of the high power electronic tube. Quartz is the best electrical insulator known to science. Many other qualities make it ideal for the job. . . . Not subject to thermal shock. Non hygroscopic. High surface resistance. Shaped to specification.

ULTRA VIOLET LAMPS (quartz mercury arcs)

HYDROGEN ARCS IN QUARTZ

FUSED QUARTZ ROD,

TUBING, PLATES and SPECIAL SHAPES

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CHEMICAL & MANUFACTURING CO.

Dept. E-11

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approximately 16.4 percent over July, 1943. Production rose five percent in June, but was still four percent behind schedule in July largely because of a 60- to 90-day lag between the new design on the drawing board and final assembly of the parts.

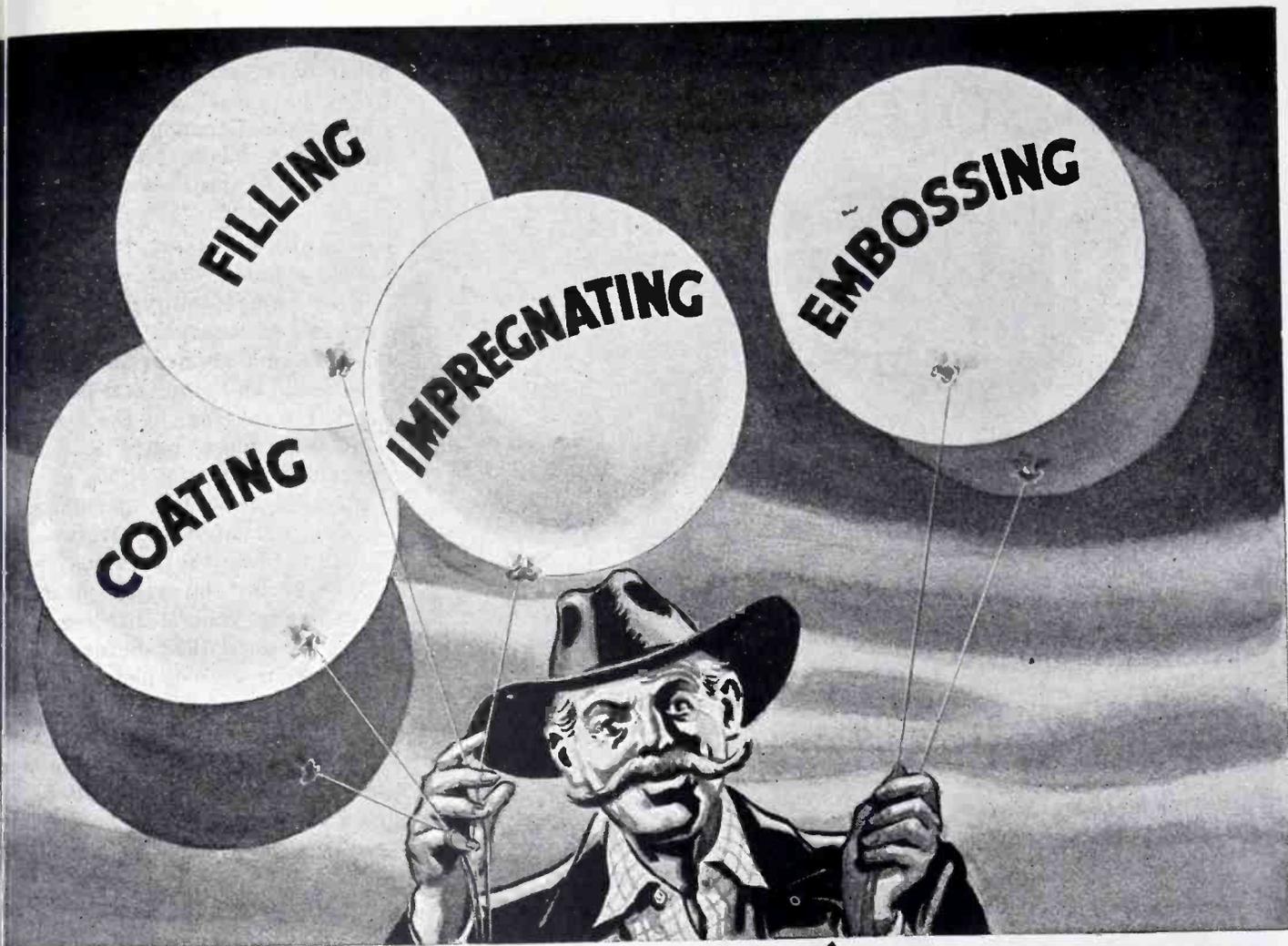
Serious manpower shortages exist in the production of certain component parts for signal equipment, such as dry-cell batteries and transformers. About 22,000 new workers will be needed in key electronic plants between now and the end of the year, WMC estimates, and an additional 12,000 a month will have to be found for replacements at the current rate.

About half the present workers are women, according to WMC, and that percentage can be stepped up to two-thirds if they can be recruited. Chief difficulty in adding to the labor force in this field, WMC points out, is that most of the plant is centered in labor shortage areas—around Chicago; near Philadelphia and Newark; and in the Buffalo, Syracuse, and Schenectady areas.

MORE BATTERIES. Demand for batteries, according to the Signal Corps officers who are charged with the duty of procuring all batteries for all the armed services, is still sharply on the upswing. Deliveries of all types of batteries have increased about two-thirds since the beginning of this year but monthly rates must be increased another 40 percent. The current monthly production of battery cells runs close to a hundred million, which is still far short of what is desired.

STATION SALES. FCC has asked Congressional direction as to the policy it should follow in passing on the sale of radio stations where the sales prices are far in excess of the going-concern and physical-property values of the stations and appear to involve considerable compensation for the radio frequencies themselves.

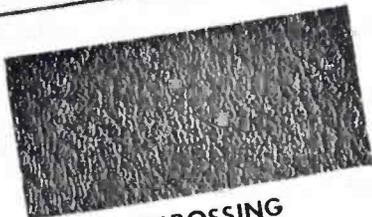
In identical letters to Senate Interstate Commerce Committee Chairman Burton K. Wheeler and to Rep. Clarence Lea, Chairman of the House Interstate and Foreign Commerce Committee, FCC chairman James Lawrence Fly suggested the "tremendously high prices" which radio stations command in the present market indicates the



And now we add *Embossing*
to make CLOTH serve more people . . . more ways . . .

Embossing is a surface treatment generally applied to coated cloth to secure a decorative effect or to simulate a naturally regular surface. One of the most common forms of embossed treatment copies various leather finishes and many so-called "imitation leathers" have all of the appearance value and

much of the durability of leather and, in addition, are waterproof, non-porous and uniform. Various coarse fabric textures are embossed as well as all-over designs. A combination of embossing with printing (color on high spots) produces unlimited pleasing contrasts.



EMBOSSING

Under pressure a relief pattern is produced in the plastic coating. The cloth structure is in no way damaged or weakened. For certain industrial uses embossing may create lines or marks of functional value.

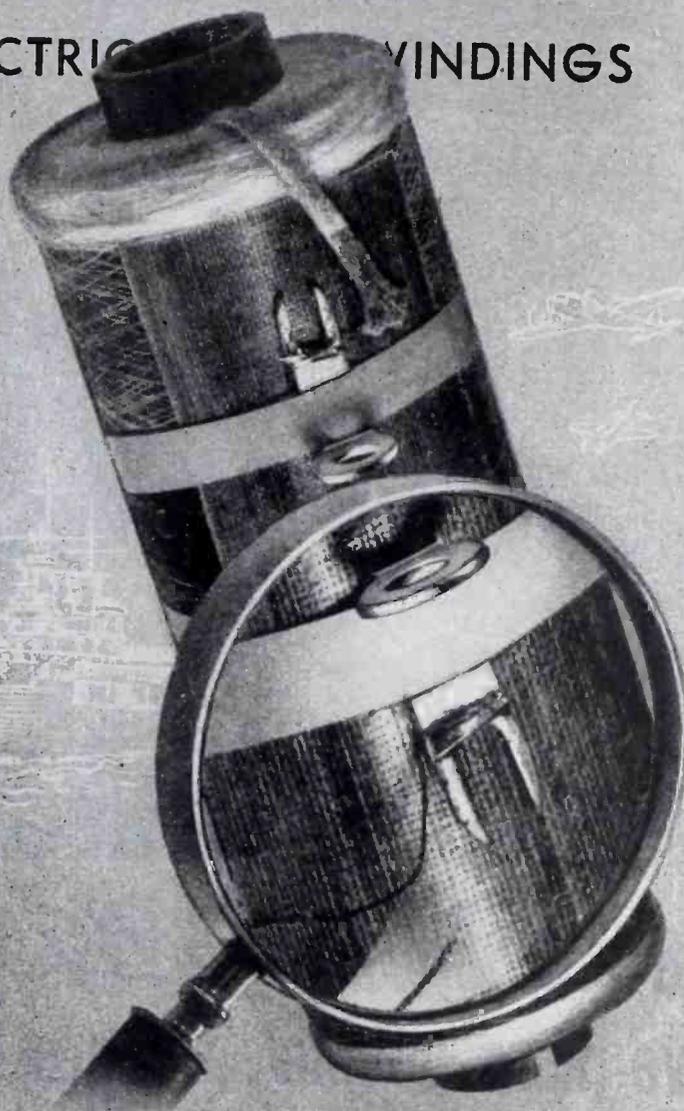
CURRENT HOLLISTON PRODUCTION includes COATED AND IMPREGNATED FABRICS . . . INSULATING CLOTH BASE . . . SEPARATOR CLOTHS rubber, starch-filled, glazed. TRACING AND BLUE PRINT CLOTHS white and blue, ink or pencil. MAP CLOTH, PHOTO CLOTH, self-adhesive. REINFORCING FABRICS. SIGN, LABEL AND TAG CLOTHS, waterproof to take any ink, meet any inking problem. BOOK-BINDING CLOTHS. SHADE CLOTH, impregnated waterproof, opaque, translucent or light proof.

We urge you to consider CLOTH, and invite you to consult with us concerning possibilities and developments for your specific requirements.

The Holliston Mills, Inc.
PROCESSORS OF CLOTHS FOR SPECIAL PURPOSES
NORWOOD, MASSACHUSETTS
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Coto-Coil

ELECTRIC WINDINGS



INSIDE STORY

- The destiny of a "flat-top" depends on this little soldered connection in a coil winding.
- And so, across the entire fighting front . . . in tanks and ships and in planes . . . the lives of our fighting men, the success of their missions and the safe return of equipment permits of no compromise in quality.
- Windings by Coto-Coil fire remote guns . . . release a single bomb or a salvo. The applications are countless . . . many cannot be told, but the importance of never failing dependability is apparent to all.
- Whether you build equipment for the armed services or for industry, you cannot afford to use any coils but the best.

COIL SPECIALISTS SINCE 1917

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sellers may be profiting from their lien on a radio frequency which they have been authorized to use under the Communications Act of 1934, but whose ownership under the Act is reserved to the public.

RADIO-PHONOGRAPH PRICING. The price schedule that previously governed manufacturers' maximum prices for consumer-type radio receivers and phonographs has been revoked, and the articles transferred to coverage by the regulation affecting most other consumer durable goods, the Office of Price Administration has announced.

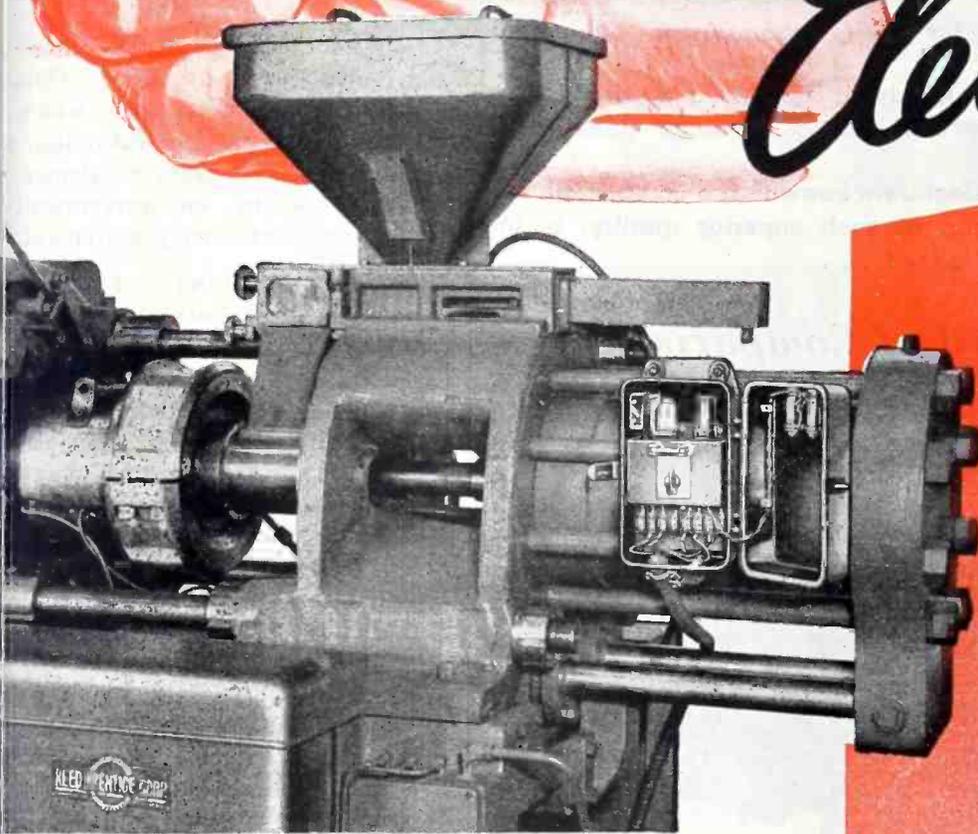
This transfer to coverage was made because the previous regulation covering the articles dealt only with price control problems that were acute in 1942, before civilian production was completely shut off, and is not suited to present conditions. In particular, it does not provide a method for pricing new models of radio receivers and phonographs.

EDUCATIONAL BROADCASTING. FCC has adopted a new application Form 340, to be used when filing an application for construction of a non-commercial educational broadcast station. This form supersedes Form 309 and supplemental Form 313 but Form 309 continues to be used for several classes of broadcast stations other than standard.

Form 340 is expected to be more convenient to applicants desiring noncommercial educational broadcast facilities, and at the same time the form will supply the Commission with additional information concerning the service planned and the technical equipment proposed to be installed. The new application form now available will be used by the many nonprofit educational agencies planning the construction of f-m broadcast stations for the advancement of their educational work and the transmission of educational and entertainment programs to the general public.

REGULATIONS FOR RADIO SERVICEMEN. Information has been compiled by domestic and foreign branch of the radio and radar division of WPB to guide radio repairmen now in business as well as exrepairmen and men discharged from military service. In order that they may

We time the Punch with *Electrons*



... so that it "lands" with the extra force needed to fill the die.

In this Reed-Prentice Plastic Injection Moulding Machine, granulated plastic material is forced through a heated cylinder into the die at continuous high speed, under high pressure. Photoswitch Electronic Timer T15U actuates controls within the hydraulic system that provide maximum pressure, at the exact instant, with the *fractional second timing required* to complete the injection stroke.

Why Electronic Timing is the Best Answer for Split-Second Repeat-Cycle Accuracy

Photoswitch Electronic Timers function with split-second accuracy . . . without fatigue . . . frictional wear . . . or inertia. Electronic operation eliminates clockwork, springs, mechanical clutches . . . all moving parts subject to wear and failure . . . provides consistently accurate control without danger of speed-up or slow-down, and with extremely long life assured. Photoswitch Electronic Timers are used extensively to initiate automatic operation of precision production grinders, millers, profilers and other machine tools; to insure maximum safety and efficiency in X-ray equipment; to provide split-second control in welding, molding, spraying . . . and to afford the high degree of accuracy needed in process control.

Write to
PHOTOSWITCH, INCORPORATED
Cambridge 42, Massachusetts
for Bulletin 900-A.

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INCORPORATED

PHOTOELECTRIC AND ELECTRONIC CONTROLS FOR EVERY INDUSTRIAL PURPOSE

BUILT LIKE A BATTLESHIP

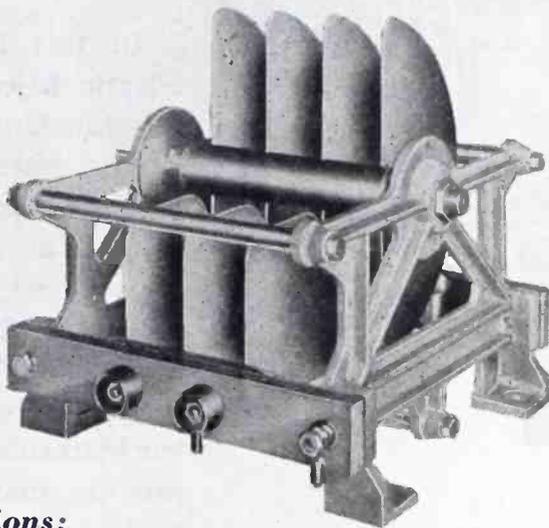
... and just as
indestructible

Discriminating radio transmitter manufacturers believe that the very best components are not too good for their high power equipment.

Such manufacturers are using Cardwell condensers typified by the Type WX-95-VS heavy duty transmitting capacitor (illustrated).

The customers of these manufacturers know that a component, embodying master craftsmanship of such superior quality, is the finest money can buy and, indeed . . .

The Standard of Comparison



Specifications:

Type WX-95-VS

Capacity—100—42 mmfds.

Airgap—1 inch.

Peak Voltage—20,000 volts.

Size—15½" x 15½" x 13¾" long.

Frame—Cast aluminum end plates with brass tie rods.

Rotor—½" brass plates pressed and soldered into solid brass barrel.

Stator—½" brass plates pressed and soldered into massive brass stator blocks; equipped with electrostatic shields, on blocks and stator studs, to minimize corona losses.

Rotor Contacts—Laminated phosphor bronze self-cleaning brush.

Finish—Polished lacquered brass—End Castings satin finish aluminum, lacquered.

Bearings—Ball thrust rear—shoulder front bearing.

Shaft Extension Diameter—½ inch.

Insulation—Mycalex.

STANDARD OF COMPARISON

CARDWELL  CONDENSERS

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION

81 PROSPECT STREET

BROOKLYN 1, N. Y.

know how to obtain necessary materials to carry on or enter in the radio repair business, they will be guided by specialists in the field service branch of regional and district offices who are familiar with WPB orders and the problems of civilian radio in wartime.

Summaries of applicable regulations include those pertaining to the creation of an inventory, replacement of components and tubes, a purchase of tools and test equipment.

Another pertinent ruling is a recent issue by OPA (Office of Price Administration) which has restricted gasoline-rationing mileage to those radio repairmen who are working on government-government-agency-equipment.

COMMUNICATIONS FELLOWSHIP
Training of Latin American engineers in the regulatory and operating procedures of communications in the United States is the aim of a program sponsored by the State Department which has allocated \$10,000 to FCC for such work. Rules and regulations have been formulated by FCC to govern the awarding of fellowships to applicants from other American republics.

Fellowships shall be of the intensive-training type which may include orientation in FCC office instruction in the engineering departments; and training in monitoring stations of the Commission besides visits to other government agencies, private communication companies, and other background sources. Rules which have been established cover qualifications, award of fellowships, allowances, and expenses.

BUSINESS NEWS

ELECTRONIC MANUFACTURERS ASSOCIATION has been formed in New York, N. Y. Membership is drawn from companies active in the metropolitan and nearby areas.

MILWAUKEE INDUSTRIAL DESIGNER has moved to new quarters at 74 North Fourth St. Milwaukee 3, Wis.

INTERNATIONAL BUSINESS MACHINES CORP. and **GENERAL ELECTRIC CO.** have collaborated on a proposed network joining Washington, New York, and Schenectady and which will operate in the region between

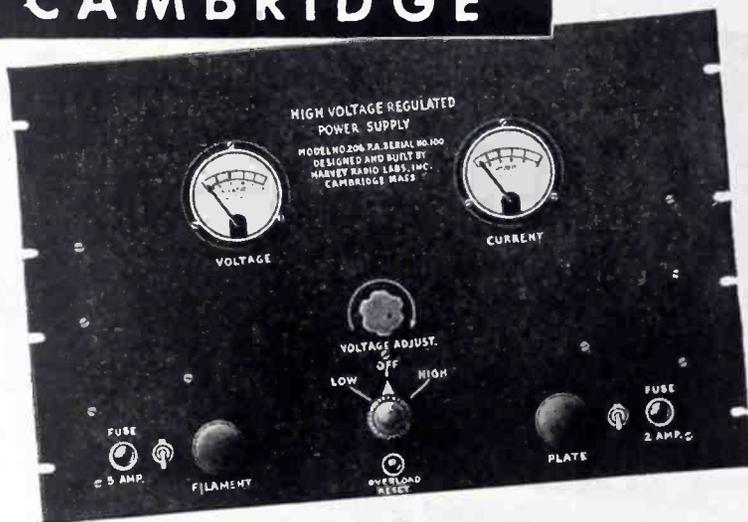


HARVEY 106 PA
200 to 300 VOLTS

HARVEY

OF CAMBRIDGE

New
HARVEY 206 PA
500 to 1000 VOLTS



for **REGULATED POWER SUPPLY**

If you're looking for a dependable, controllable source of laboratory D.C. power for operation with pulse generators, measurement equipment, constant frequency oscillators, amplifiers and other equipment requiring a constant flow of D.C. voltage, it will pay you to get in touch with Harvey of Cambridge.

The Harvey Regulated Power Supply 106 PA will meet your every requirement in the lower voltages. It has a D.C. output variable from between 200 to 300 volts that is regulated to within one per cent.

The New Harvey Regulated Power Supply 206 PA is for higher voltages. This latest Harvey development operates in two ranges 500-700 at $\frac{1}{4}$ of an ampere and 700 to 1000 at .2 of an ampere. Both ranges have accurate regulation to one per cent or better.

Whatever your requirements, one of these Harvey Regulated Power Supply units will meet them with efficient, dependable performance.

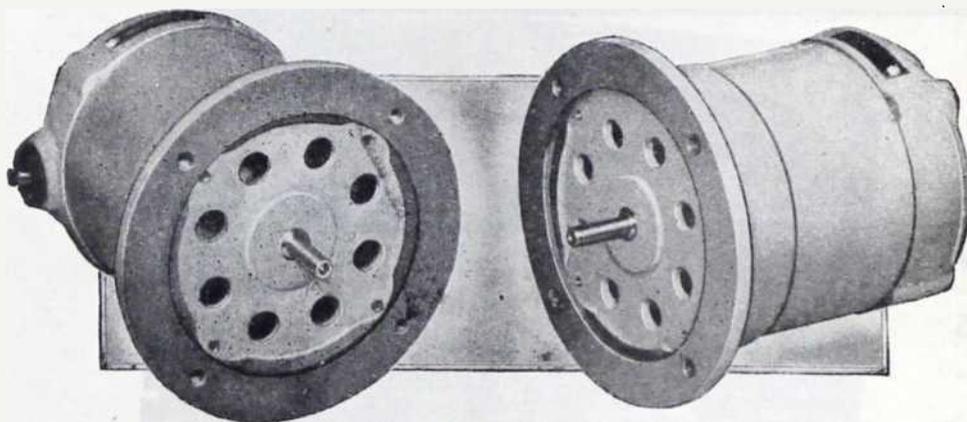
We'd be happy to supply you with complete information on either or both of them.



HARVEY RADIO LABORATORIES, INC.
439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

OHIO

MOTORS for ELECTRONIC APPLICATIONS



1/30 HP—115 V—60 Cy.—A. C.—1 Ph. 1725 RPM. C. C. Flange Mounting. Ball Bearing.

Cut shows one of many types and sizes of Ohio Motors designed for driving Electronic Devices.

RANGE

1/100 to 2 HP.—A.C.

1/100 to 1 HP.—D.C.

1/100 to 1/4 HP.—A.C. Synchronous.

1 to 100 oz. ft. A.C. Torque.

Shell type motors for built-in applications to 4 HP.—D.C. and to 7 1/2 HP.—A.C.

All usual voltages and cycles.

What is your problem?

THE OHIO ELECTRIC MANUFACTURING CO.
5908 Maurice Avenue Cleveland 4, Ohio

tween 1900 and 2300 Mc. Facilities are to be used for relay purposes possibly including television, facsimile, radiotype, and facsimile.

MERIT COIL & TRANSFORMER CORP. has completed a new plant at Chicago, Ill., and will combine general offices with production facilities there.

AMERICAN TELEPHONE & TELEGRAPH CO. and SOUTHERN BELL TELEPHONE & TELEGRAPH CO. have been given FCC permission to spend an estimated \$6 million on coaxial lines between Atlanta, Ga., and Dallas, Tex.

PENNSYLVANIA RAILROAD has planned to equip its Harrisburg main-line division with radiotelephone equipment in 300 freight and passenger locomotives and 90 cabooses. Cost has been set at \$1 million.

DEJUR-AMSCO CORP. has completed plant No. 2 in Long Island City, N. Y. Facilities cover 75,000 sq ft.

NATIONAL RADIO INSTITUTE, Washington, D. C. has completed 30 years of service to the industry.

PRESS WIRELESS INC. has arranged to move its executive offices from Chicago to 1475 Broadway, New York, N. Y.

RCA VICTOR DIV., RADIO CORP. OF AMERICA will introduce the first electron microscope into the laboratories of Australia for war production research. It will be delivered to the Council for Scientific and Industrial Research.

FAIRCHILD CAMERA & INSTRUMENT CORP. has been assigned an approved quality-control rating by USAAF. This means that duplicate Army inspection during detail fabrication will be eliminated and the company will be given full responsibility.

RCA VICTOR DIV., RADIO CORP. OF AMERICA, has finished its millionth Type X crystal which was placed in a gold-plated container for ceremonial purposes.

PRATT INSTITUTE, Brooklyn, N. Y. has announced a forthcoming series of tuition-free ESMWT courses including introduction to radio, radio



For Your Postwar Needs in Connectors and Related Units

If your postwar plans will involve coaxial cable connectors, cable plugs or special design parts of similar nature—we invite your consideration of our products and facilities.

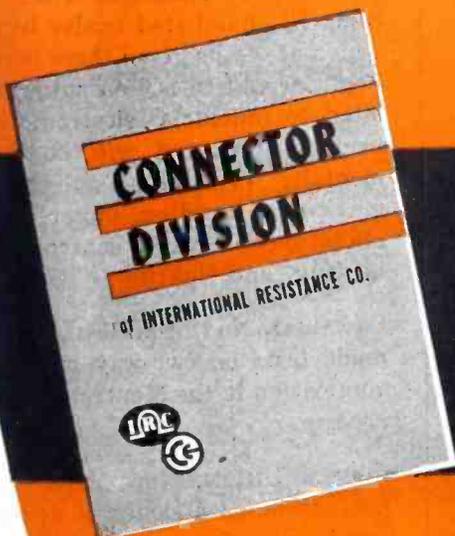
Besides offering a comprehensive line of standard units, Connector Division possesses a unique engineering skill and knowledge in this field that may prove of valuable help and economy to you.

INTRODUCING MINIATURE BATTERY PLUGS



(Illustrations are actual size)

Anticipating the trend to midget devices, IRC presents this new, easy-grip battery plug. Pins are firmly imbedded in molded bakelite to insure positive contact. Side-positioned lead entries reduce strain on soldered connections. Fitting all miniature batteries, these plugs should find wide application in many types of equipment especially in the radio, hearing-aid, medical apparatus, and appliance fields. Available in two-pin or three-pin models. Specifications and samples on request.



Write for Catalog



*CONNECTOR DIVISION OF

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401 N. BROAD ST., PHILADELPHIA 8, PA.

*FORMERLY CONNECTOR CORPORATION

YOUR COPY IS READY FOR MAILING



This new 44 page book gives you the complete story of "SPRING-LIFE" BELLOWS

By engineers—for engineers—yet with information and illustrations so complete that all men engaged in manufacturing can gather a full knowledge of bellows and their functions. This informative book tells all about "Spring-life" Bellows, including their characteristics, construction and applications, plus data charts and other valuable information to assist engineers in determining bellows requirements.

Also included in this book are illustrations and information pertaining to Cook Pressure Detector Switches, and an introduction to the Cook "MetaLastic" Division. This catalog will be sent to you immediately upon receipt of a request on your letterhead.

Remember, if you have an extremely urgent problem, wire or 'phone us, and we shall be pleased to quickly dispatch a field engineer from one of our district offices to assist you.



2700 SOUTHPORT AVENUE • CHICAGO 14, ILLINOIS

construction and testing, elements of electronics, industrial electronics, and u-h-f techniques.

GENERAL ELECTRIC Co., Schenectady, N. Y., has launched a program which will eventually see all the parts of its electronic activity centered in an industrial development on the outskirts of Syracuse, N. Y. Construction of the plant has been planned for the end of wartime.

KANSAS CITY & SOUTHERN RAILROAD has completed an installation of two-way radiotelephone communication along its entire main-line 560-mile right of way.

RCA VICTOR DIV., RADIO CORP. OF AMERICA, has established a comprehensive re-employment program which will affect the 6000 former workers serving in the armed forces.

GALVIN MFG. CORP. has installed a two-way f-m radiotelephone communication system which gives instant contact throughout the entire length of the Panama Canal.

FORT WORTH ELECTRONICS CLUB has been organized by 19 charter members connected with local industries. Monthly meetings are scheduled.

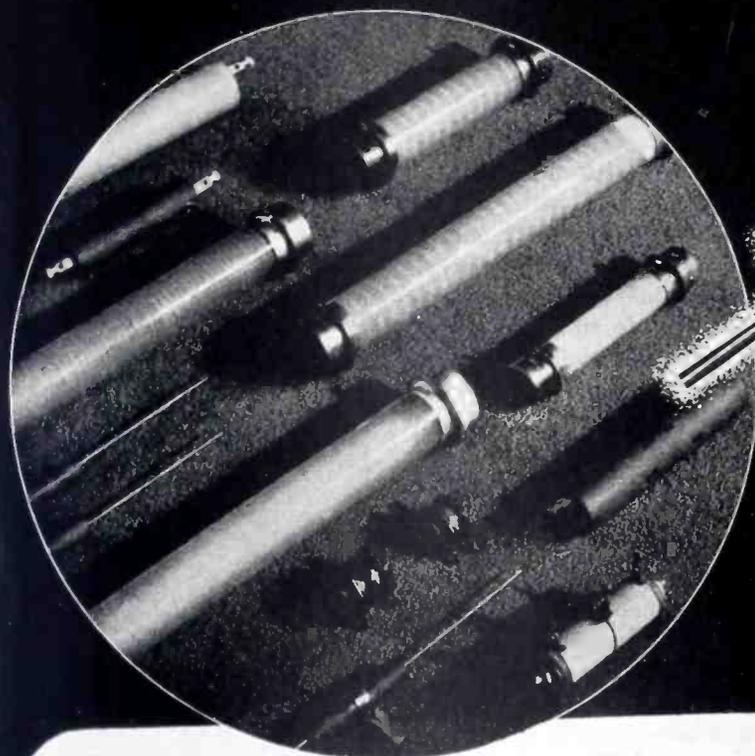
DEFORST'S TRAINING INC., Chicago, Ill., has listed twelve lectures which are to be given there between Sept. 20 and Dec. 6 on subjects related to industrial electronic engineering. Covered will be fundamentals, rectifiers, thyatrons, measuring, welding, motor control, phototubes, elevator control, x-ray, heating, and lighting.

CANADIAN NATIONAL RAILWAYS has made tests on two-way radio communication in the Montreal terminal area.

COOPER UNION, New York, N. Y., has scheduled a series of engineering courses for evening attendance starting Oct 2. Communications principles, advanced electric circuits, and electrical engineering for other than electrical engineering students are to be included.

NEARLY \$9,000,000 worth of equipment would be needed if the FCC were to approve the applications for FM stations now on file.

DON'T LET OLD-FASHIONED RESISTORS CRAMP YOUR ENGINEERING STYLE!



The only
Resistors
wound with
CERAMIC-INSULATED
WIRE

**INSULATION APPLIED
BEFORE WIRE IS WOUND**

A Major Resistor Improvement—*Not just a minor change*

Don't waste time engineering "around" the handicaps imposed by conventional resistors! Use Sprague Koolohms and get exactly what you want.

No power resistor can be one whit better than the insulation given its windings—and Koolohm ceramic insulation applied to the wire before it is wound gives you the maximum in this respect. Koolohms can be used safely up to their full rated wattage values. Their use of insulated wire permits larger wire sizes to be used,

and guards against shorts and changed values. They give more resistance in smaller size, and are readily adaptable to almost any mounting style best suited to your production.

Standard Sprague Koolohms include 5- to 120-watt power types. Other Sprague Resistors include bobbin types, hermetically sealed power resistors, 5- to 150-watts, and meter multipliers. Write for new catalog—just off the press.

SPRAGUE ELECTRIC COMPANY, Resistor Division
(Formerly Sprague Specialties Co.)
North Adams, Mass.



SPRAGUE * KOOLOHMS

Totally Different . . . Outstandingly Superior

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Vibration Fatigue Testing Machine

MODEL 10-HA is a vibration fatigue testing machine which is designed to meet all requirements for a fatigue testing machine that will subject parts up to 10 lb in weight to vibration produced horizontally in simple harmonic motion. It has a range from 10 to 55 cps (600 to 3,300 vibrations per minute) which are increased and decreased automatically at a uniform rate.

A 4-page bulletin, No. 610, describes and illustrates Model 10-HA, as well as other vibration machines available from All American Tool & Mfg. Co., 1014 Fullerton Ave., Chicago 14, Ill.

Direct-Recording Electrocardiograph

INSTANTANEOUS, permanent, standard readings may be obtained with this inkless, direct-recording electrocardiograph (Type EPL) which is for use in electro-medical analysis and laboratory research. The instrument is compact, lightweight and portable, and requires no photographic processing. The recorder may be used in conjunction with other equipment for laboratory research. The electrocardiograph

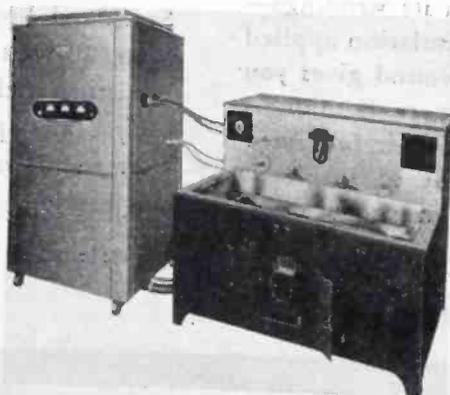


comes supplied with an amplifier and recorder which will give a graphic record between 0.1 and 80 cps at a sensitivity of 1 millivolt and 2 cm total deflection or a range from zero to 80 cycles for 60 millivolts and 2 cm deflection. A high speed writer can be supplied which will extend the frequency range to approximately 200 cycles. The phase correction is such that perfect square-wave response from 0.5 to 80 cycles is realized with the one-millivolt sensitivity connection.

Electro-Physical Laboratories, Inc., 45 West 18 St., New York, N. Y.

Hardening and Quench Table

ILLUSTRATED IS A general-purpose, two-station hardening and quench table used in connection with high-frequency induction heating generators. The unit is suited to a wide variety of machine parts requiring surface hardening or localized heat-



ing. The table has quick-change coil connections so that jobs can be set up in 2 to 3 min to change a heating coil. The unit is flexible enough for low production requirements. An initial timer is provided to indicate the heating time for a new job or a new part and no stop

watch or other means of timing necessary. After the initial heating time has been determined, the time can be cut out by means of a selector switch which is included in the assembly. A 3-stage timer automatically controls the heating and quenching positions of the cycle. A signal-type pilot light indicates heating is taking place.

Induction Heating Corp., 389 Lafayette St., New York 3, N. Y.

Secondary Frequency Standard

THIS SECONDARY FREQUENCY standard is crystal controlled with a hermetically-sealed MD cut dual-frequency crystal. It provides useful output up to 40 Mc at 1,000-kc

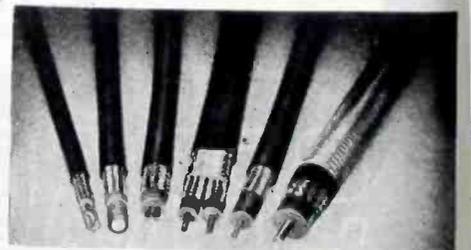


100-kc and 10-kc intervals. It operates from 60 cps, 115 v line. The unit is housed in a sturdy metal cabinet.

The James Knight Co., Sandwich, Ill.

New Type of UHF Cables

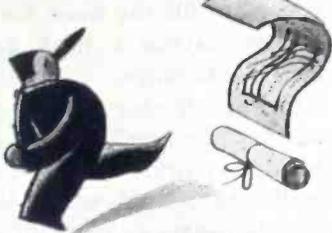
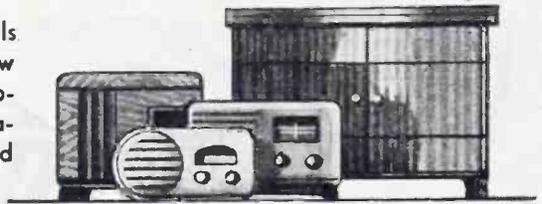
NEW SIZES AND TYPES of solid-dielectric coaxial cables, used in uhf and radar equipment for the armed services, have been added to this manufacturer's line of cables. The cables are manufactured in five basic types:



Basic types of high-frequency cables. From left to right: coaxial air-spaced, spiral delay, twin-conductor, dual-coaxial, coaxial solid dielectric and armored coaxial cables

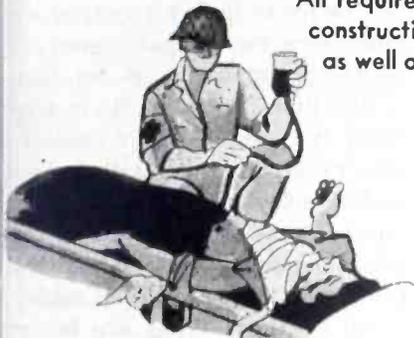
The ECA STORY

For almost a quarter of a century, most of the principals and personnel of ECA have had the opportunity to grow and expand with electronics. We've had experience producing many different types of highly specialized apparatus—including sound systems, test equipment and other electronic devices.



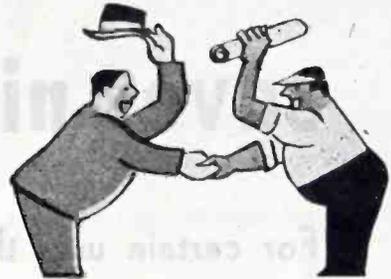
ECA engineers, designers and technicians are all accustomed to working to exacting laboratory standards. Rich in the fundamentals of radio and electronics, we can approach any problem with full confidence that the ultimate result will prove eminently satisfactory.

Naturally, during these crucial war years, our entire production is devoted to materials needed by the Armed Forces. Much of this equipment is of an extremely delicate and precise nature. All require maximum attention to design and construction to meet the standards of ECA as well as the government.



While devoting our working time 100% to war production, we have not forgotten home front activities. The Electronic Corporation of America is proud that each succeeding war bond drive has been over-subscribed, and we're equally proud of the blood donor award given to us by the American Red Cross.

Regularly at ECA, representatives of management meet with representatives of labor to discuss company policy, to fix production quotas, and to look after the needs of the individual worker. We have found that harmonious labor-management relations stimulate the output, efficiency and progress of our organization.



Under these splendid conditions will future ECA products be manufactured. Modern production techniques, trained personnel and precision laboratory and plant facilities will be utilized to produce superior ECA radios and electronic devices for home, industry and medical science. This, in effect, is the ECA story.

We shall be pleased to send you our new publication on...

What are the prospects for the future? How can America's vast industrial set-up be put to most effective use for a prosperous and abundant economy? What are the joint responsibilities of management and labor? Can small business survive? How can American business and industry achieve additional markets worth at least 25 billion dollars? Is the attainment of full scale employment a wishful dream or an actual possibility? The answers to these, and other vital questions, are supplied in "A Plan for America at Peace." Write for your copy... we'll gladly send it to you without charge or obligation.



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ELECTRONIC CORP. OF AMERICA

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ECA will offer a new plan of distribution of the Electronic Parts and Equipment Industry Conference in Chicago. Be sure to talk to us about it.

a stitch in time



saves nine . . .

For certain uses there is no substitute for Mica. When substitution is attempted trouble follows.



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The first of these is called Coaxial. This line includes sizes from 1/8 in. outside diameter up to and including cables over 1 in. in outside diameter. Standard designs include single and double-braided constructions with standard and armored covering.

Dual-coaxial lines have been developed to fill the need for parallel circuits having a high degree of electrical balance.

Twin-conductor lines, sometimes called "Twinax" are balanced shielded pairs, usually somewhat smaller than dual-coaxial lines, and provide nearly as good an electrical balance.

For low capacitance requirements, there is available a line of coaxial air-spaced cables which can be made in any required length and which have capacitances as low as 8 micro-microfarads per foot.

The fifth type of cable is a spiral delay line which is for special test sets requiring lines with an appreciable delay or very high impedances. Some of these lines have in 1-ft. length an electrical equivalent to that of 15 ft of coaxial cable.

All of these types are designed generally, for 50 to 70 ohms impedance, and the type of cable selected is predicated by power requirements or power loss limitations.

A bulletin called "Intelin Coaxial Cable Impedance Nomographs" is also available.

Intelin Products Div., Federal Telephone & Radio Corp., Newark, N. J.

Alignment Tool

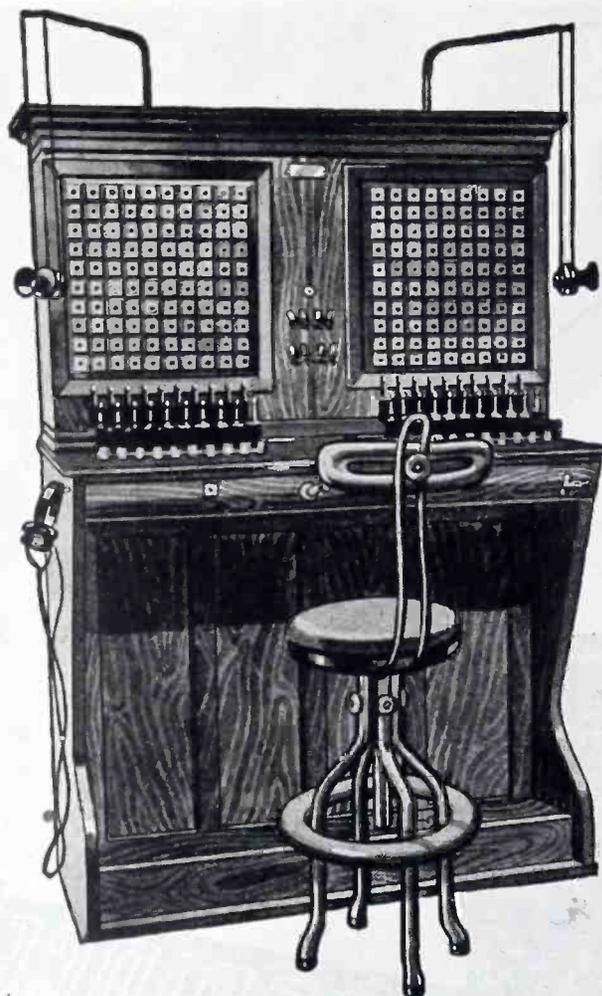
A NEW TOOL FOR precision alignment of padding capacitors in radio receivers and transmitters is Type TL-207 which is available from General Cement Mfg. Co., Rockford, Ill.

Shockproof Relays

THESE RELAYS ARE wound to specifications and are available in single or double pole. They have been subjected to vibration and other tests. A single relay measures 1 1/2 in. wide, 2 3/4 in. long and 1 1/2 in. high.

H. C. Evans & Co., 1528 W. Adams St., Chicago, Ill.

**"They make
everything
in their line
from the raw
material to
the finished
product."**



This sentence was written about a news-worthy feature of Connecticut Telephone and Electric operations nearly forty years ago. It has been important ever since.

This Division's facilities for complete fabrication of electrical parts and devices within its own plants are unusual. Because of them, the production of vital communications equipment, aircraft ignition devices and other urgently needed war material is being speeded. It permits important manufacturing economies. It gives us better control of the equipment we make. These things are important in war and peace alike.

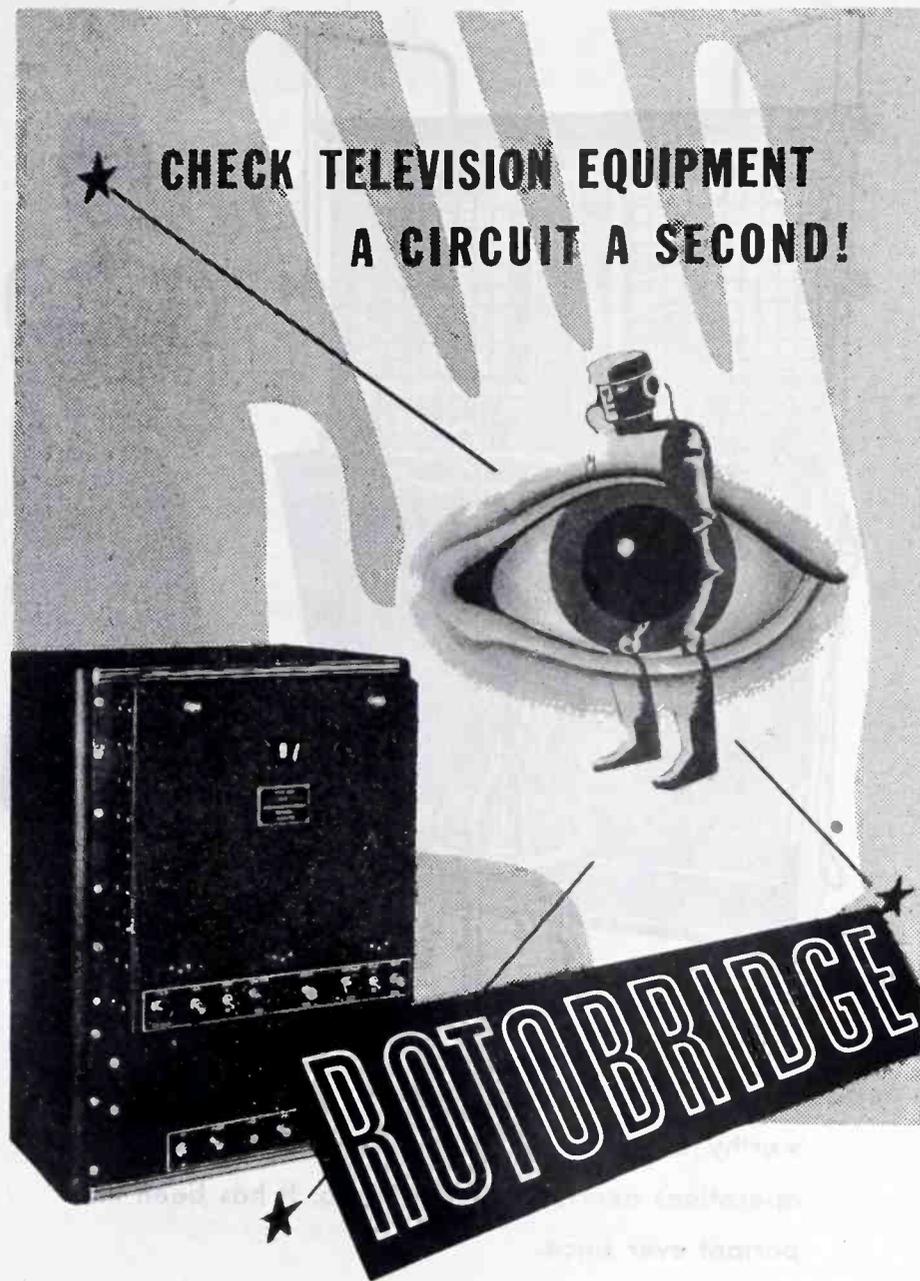
CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES, INC.

MERIDEN, CONNECTICUT

TELEPHONIC SYSTEMS • SIGNALLING EQUIPMENT • ELECTRONIC DEVICES • ELECTRICAL EQUIPMENT • HOSPITAL AND SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS • IGNITION SYSTEMS





THE AUTOMATIC ROBOT INSPECTOR

Television—as well as any other type of electronic equipment—can be checked with the ROTOBRIDGE . . . for wiring errors, for resistance and reactance values.

Versatile and vigilant, the Rotobridge is designed for intensive, 24-hour duty. With robot-like fidelity and exactness, the Rotobridge does what you want it to do, without hitch or hesitation. A 10% resistance tolerance at one point? A 25% capacity tolerance elsewhere? You get it with the Rotobridge . . . where and as you want it . . . accurately, automatically. And when the Rotobridge detects an error, it stops dead and instantly flashes a red warning signal—and keeps on flashing it until its human co-worker attends to the defect.

The Rotobridge can be put to work on several small sub-assemblies or on a complete set, involving as many as 120 circuits. Two or three of these robots working simultaneously are all you need to inspect a 30 or 40 tube set-up. And they'll do it in five minutes flat!

Write for complete details.

COMMUNICATION MEASUREMENTS LABORATORY

120 Greenwich Street

New York 6, N. Y.

Thermoplastics Welding Machine

THIS MACHINE utilizes high-frequency current to weld many types of thermoplastics material. It is capable of welding about 35 ft. per minute. The weld created is watertight, moisture-proof and airtight. The machine itself resembles an



ordinary sewing machine, but a welder can be modified to other physical forms and can be adapted as a step in the process of fabrication, or can be incorporated in other machines. The manufacturers state that the machine is not ready for distribution.

Richardson-Allen Co., 15 West St., New York, N. Y.

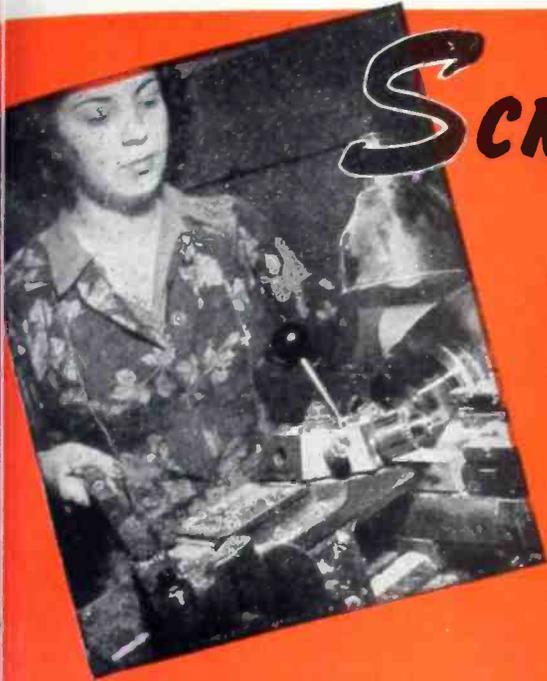
Electron Tubes

AVAILABLE TO equipment manufacturers against WPB rated orders are the following new electron tubes:

1P29 is a gas phototube (violet-green sensitive) for colorimeter applications. Spectral response occurs over the spectral range from about 4000 to 8000 Angstroms, with maximum sensitivity at approximately 4200 Angstroms. Sensitivity at maximum response is 0.1 microamp per microwatt of radiant flux.

3B25 is a half-wave gas rectifier of a hot-cathode type. It is xenon filled and is ruggedly constructed to withstand severe vibration. It can be operated under conditions where ambient temperatures of -75 to $+90$ deg C are encountered. The tube will withstand a peak inverse voltage of 4000 volts and will deliver an average anode current of 0.5 amp.

6AL5 is a miniature twin diode featuring high permeance. It is for use as a detector in circuits utilizing

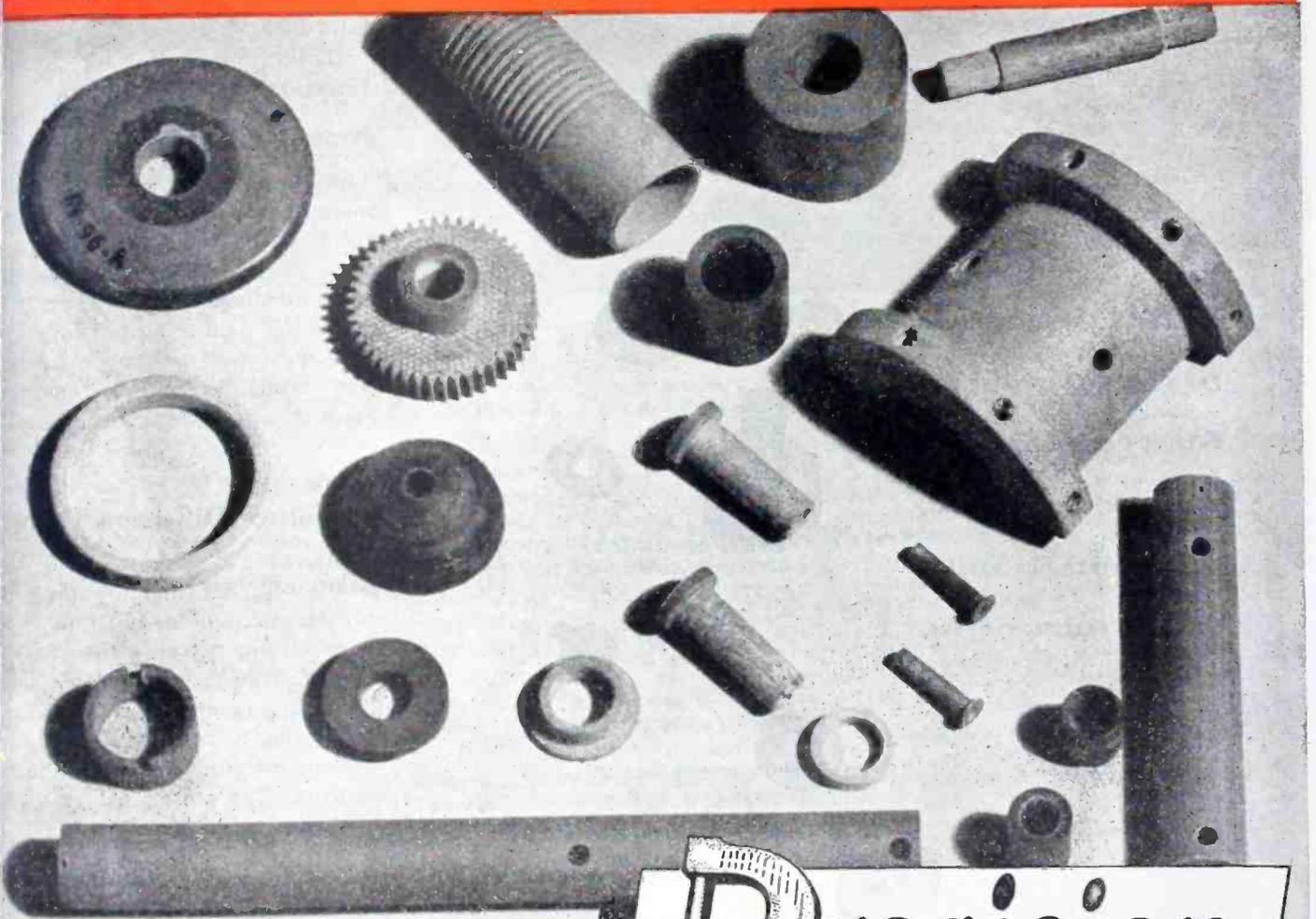


Screw Machine Parts

FROM PHENOL FIBRE, VULCANIZED FIBRE, LUCITE, POLYSTYRENE OR ANY OTHER SPECIFIED PLASTIC MATERIAL

Producing Screw Machine Parts in large or small quantities is but one of our many specialized functions as specification fabricators. Here, in our modern plant, skilled operators fashion many such parts of all sizes and shapes from many different materials on precision machines which guarantee accuracy to extremely close tolerances.

Send us the specifications for your next screw machine requirements and let us prove to you that we can produce these parts better . . . faster . . . and more economically! We have a large stock of standard materials on hand at all times—all of which meet Army, Navy and Air Corps specifications.



recision
FABRICATORS, INC.

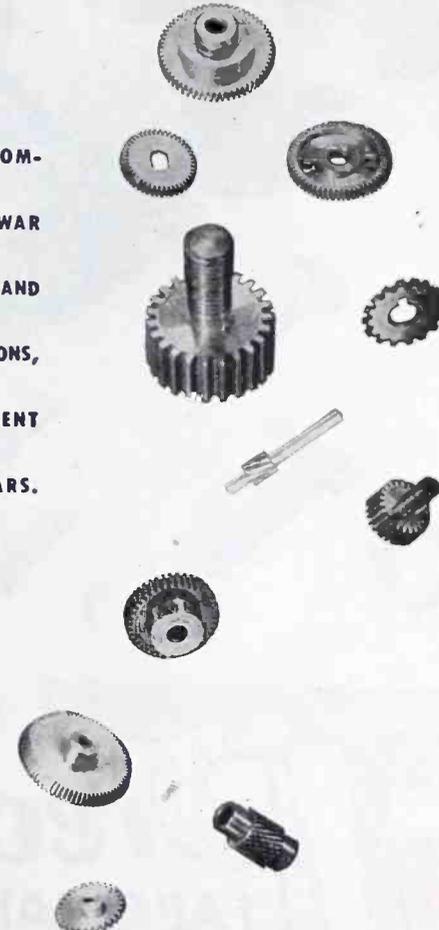
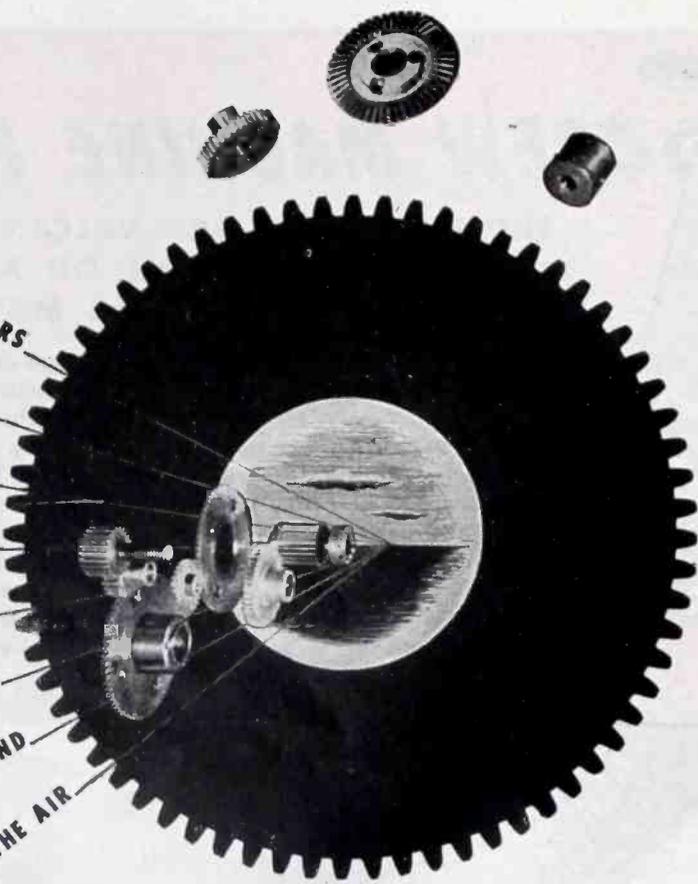
112 N. FITZHUGH ST., ROCHESTER 4, N.Y.

Specification Fabricators of
GLASS BONDED MICA, PHENOL FIBRE,
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ELECTRONICS GEARS
MUST BE ACCURATE
WITHOUT EXCEPTION
FOR USE IN ARMY—
NAVY RADIOS AND
INSTRUMENTS
ON LAND, SEA, AND
IN THE AIR

ACCURACY CANNOT BE COM-
PROMISED WITH IN THESE WAR
DAYS OF LIGHTNING SPEEDS AND
WORLD WIDE COMMUNICATIONS,
ALL TUNED INTO OUR PRESENT
TEMPO BY PRECISION GEARS.



Quaker City Gear Works

INCORPORATED
 1910-32 North Front Street, Philadelphia, Pennsylvania

ing wide-band amplifiers. It has low internal resistance and will give an increased signal voltage from a low-resistance diode load. Each diode unit can be used independently of the other or combined in parallel or full-wave arrangements. This tube is an Army-Navy preferred type.

6F4 tube is an acorn triode of the heater type intended for use primarily as an oscillator at frequencies up to about 1200 Mc. Its features are high permeance and reduced lead inductance. At moderate frequencies (in class C oscillator service with 150 volts on plate) a single 6F4 tube is capable of giving a power output of approximately 1.8 watts. At 1200 Mc and with 100 volts on plate, approximately 45 milliwatts can be obtained.

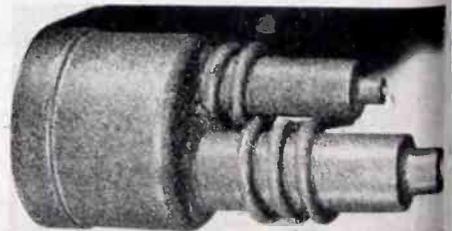
Radio Corporation of America
 Harrison, N. J.

New Tubes

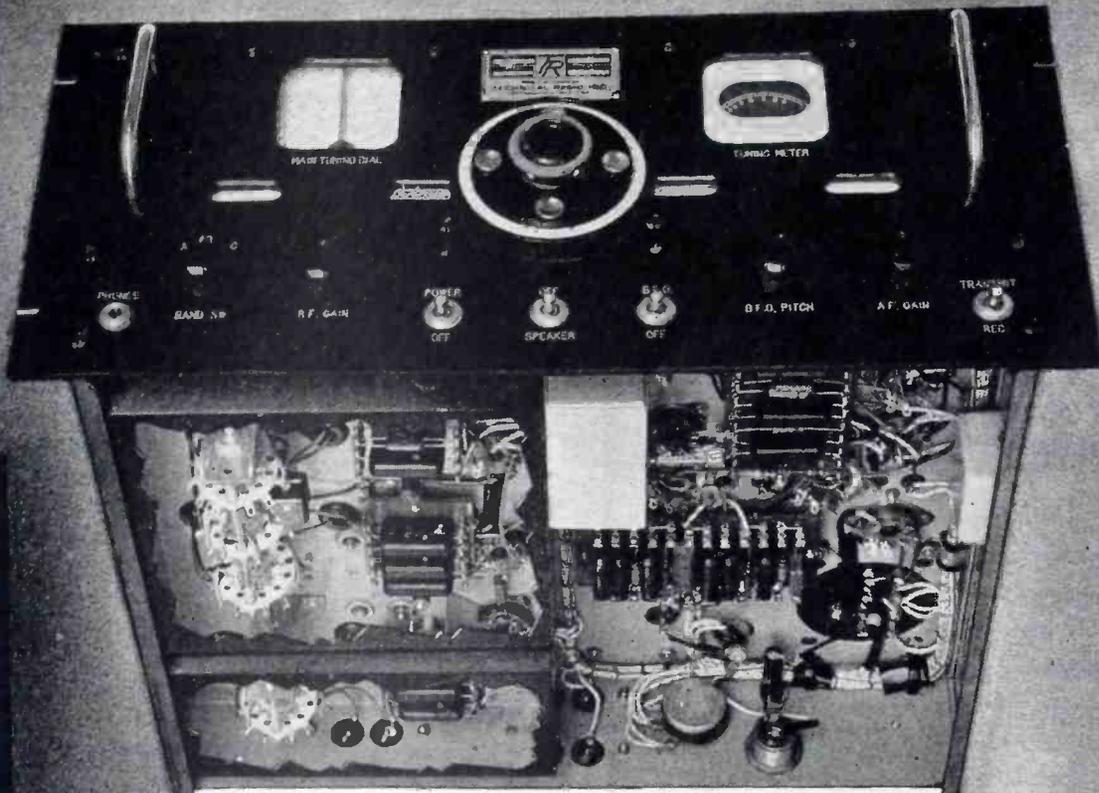
THREE NEW TUBE TYPES available include 6AK5, which is a sharp cutoff r-f pentode; the 6AL5, a vacuum twin diode; and the 6AQ6, which is a double-diode-triode. These tubes are being manufactured in accordance with WPB-authorized production schedules and are available from Hytron Corp., Salem, Mass.

Miniature Diffusion Pumps

DESIGNATED AS Type VMF, these small, compact metal pumps produce a vacuum of 10^{-6} mm of hg. They are for use with the new-style rotary exhaust machines in which a diffusion pump moves around with each tube, as well as for portable electron microscopes and similar apparatus. The pumps utilize a fractionating principle which does not require any liquid air trap. Heat transfer problems are eliminated by a boiler design. The units are normally cooled by water, but special air-cooled models are also available. The pumps are available in three



LRR SERIES



VIEWED FROM ANY ANGLE— QUALITY PREDOMINATES!

ALL COMPONENTS ON TERMINAL BOARDS THAT
USE DOUBLE BARRIER TERMINALS—EASY SERVICE

TERMINAL BOARDS VACUUM IMPREGNATED WITH
FUNGICIDE VARNISH—MOISTURE PROOF

VINYLLITE AND GLASS INSULATED WIRE—
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PLATING AND PAINTING THAT WILL WITH-
STAND NORMAL SALT SPRAY TESTS

OIL FILLED PAPER FILTER CONDENSERS—
BY-PASSES PAPER, MOLDED IN BAKELITE

AUDIO TRANSFORMERS ARE IN HER-
METICALLY SEALED CASES

F. C. C. APPROVED FOR LOW RADIA-
TION FROM H. F. OSCILLATOR —

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nothing for granted.*

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275 NINTH ST., SAN FRANCISCO, CALIF., U. S. A.

EXPORT AGENTS: FRAZAR & HANSEN, 301 CLAY ST., S. F., CAL.

FOR HIGHER THERMAL EXPANSION

We
CHACE
Manganese
ALLOY
No. 772

THE temperature coefficient of expansion of Chace Manganese Alloy No. 772 is twice as great as that of ordinary steel . . . considerably higher than aluminum, particularly at elevated temperatures . . . and far beyond that of any other strong alloy. Its expansion rate is independent of thermal treatment, and is not altered by cooling to -100° F. Thus it makes possible unusual differential expansion designs.

Chace Manganese Alloy No. 772 affords an unusual combination of useful engineering properties. It has an electrical resistivity about 60% higher than most resistance alloys in common use . . . a thermal conductivity only about 2% the value of copper . . . a vibration damping constant about 25 times greater than steel. It can be machined, stamped, drawn, extruded, and welded to itself or other metals.

AVAILABLE IN
 STRIPS SHEETS RODS AND SPECIAL SHAPES

Complete engineering and research facilities available . . . Bulletin No. A-942, giving detailed information regarding Chace Manganese Alloy No. 772, sent on request.

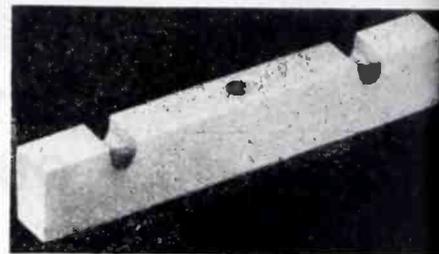
W.M. CHACE CO.
Manufacturers of
 Thermostatic Bimetals and Special Alloys
 1630 BEARD AVE • DETROIT 9, MICH.

different sizes: VMF-6 measures $2\frac{3}{4}$ in. in diameter and 6 in. high; VMF-20 measures $5\frac{1}{2}$ in. in diameter and $9\frac{1}{2}$ in. high; and VMF-10 which measures $7\frac{1}{4}$ in. high, $3\frac{3}{4}$ in. wide, and weighs 25 lb. Other characteristics of type VMF-10 are speed 10 liters/sec. at 10^{-4} mm hg; ultimate vacuum 1×10^{-6} mm hg with Octoil-S; required forepressure 0.125 mm hg; heater power 135 watts.

Distillation Products, Inc., Rochester, N. Y.

**H-F Coil Supports
 Made of Nylon**

PRINTLOID, INC., (91 Mercer St., New York 12, N. Y.) have issued a release in which they say that it is expected that when the supply of Nylon becomes sufficient for all needs, it will make its appearance in the form of rods, sheets and tubes, just as most other plastics. As a prelude to such production, DuPont recently produced a small quantity of Nylon in sheet form.



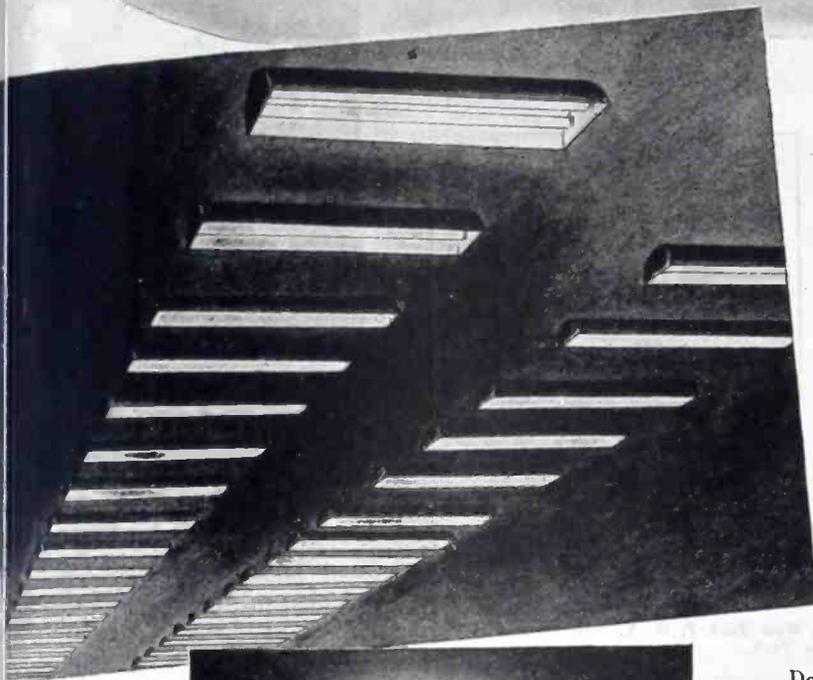
These sheets were made experimentally in small moulding presses by laboratory methods. Federal Telephone & Radio Corporation required a quantity of high frequency coil supports for some equipment they were producing. Printloid, Inc., fabricated these parts out of the new experimental sheets. Printloid will welcome inquiries concerning Nylon for electronic and other vital war uses.

Hermetically-Sealed Leads

THESE LEADS ARE constructed of Pyrex glass with Kovar electrodes and Kovar metal collars. They may be used in transformers, capacitors, coils, filters, and any other component requiring good lead-termination. A variety of standard sizes and shapes are available, and any shape or size can be furnished upon specification. The leads have high dielectric strength and are practically immune to thermal or me-

FIBERGLAS*

Electrical Insulation Tapes



Permit substantial
space and weight savings in

FLUORESCENT

Ballast Coil

Design and Construction

• • •

*Smaller, lighter, sign-lighting control
and signal transformers also possible*



Fiberglas tapes are available in tight and medium weaves, in all widths commonly required for insulating electrical products, in thicknesses of .003", .005", .007", .010" and .015".

Do you have a critical space problem—in ballast coils, transformers or other electrical equipment—where bulky insulations on the wire and around the coils are major factors in establishing the size and weight of your design? Then don't overlook the exceptionally low space factor of Fiberglas insulation—particularly tapes.

If space is at a premium—remember that a thinner inorganic Fiberglas tape will do the job of a thicker organic tape. And, too, Fiberglas tape will take much less space than equivalent inorganic materials. Because Fiberglas tape has superior tensile strength, it also permits a tighter, more compact wrapping of coils.

Besides low space factor and less weight in designed product, Fiberglas insulations have other advantages, for example:

- **High thermal resistance.** Although total effectiveness of insulation depends on impregnation, Fiberglas forms an insulating base which does not deteriorate from heat far above that encountered in electrical apparatus.
- **No change with age**—of particular importance in stand-by equipment, or where equipment stands idle over long periods of time. The glass fibers do not deteriorate, even though moisture should penetrate the outer impregnation.
- **Not affected by moisture or most acids.** Again, total effectiveness depends on impregnation, but should impregnating varnish fail, moisture will not disintegrate the glass fibers—and often will permit motor to be dried out and run again.

Fiberglas electrical insulations are immediately available in all the forms and sizes used in the electrical industry. For complete information, write *Owens-Corning Fiberglas Corporation, 1860 Nicholas Building, Toledo 1, Ohio; in Canada, Fiberglas Canada, Ltd., Oshawa, Ontario.*

WHAT IS FIBERGLAS?

Fiberglas is the trade name for glass in the form of fine fibers or filaments. These fibers are twisted into yarns, served on wire, woven into tapes and cloths, braided into sleeveings, or twisted into cords—untreated or treated—to fill every electrical insulation need.

FIBERGLAS

*T. M. Reg. U. S. Pat. Off.

ELECTRICAL INSULATIONS



YARN • TAPES • CORD • SLEEVING • CLOTH AND OTHER FORMS

Gothard NEON PILOT LIGHT

3000 Hour
Continuous Operation

Warm Glow
Visible from All Angles

The Gothard Neon Lamp Pilot Light will burn continuously for approximately 3000 hours, as compared with the approximate 500 hour life of ordinary lamps. It operates on 110 volts and consumes only 1/4 watt. The unbreakable lucite protective cap, designed and made for Gothard exclusively, provides perfect light dispersion of its warm neon glow in all directions. Lucite cap unscrews for lamp change. Bakelite socket. Polished and chrome plated jewel holder. 1" mounting hole. Colors: red, green, amber, blue and clear. Ask for complete information on this and wide range of the Gothard Lights.



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Star Steatite is HARD!

Extremely rugged and tough, STAR STEATITE is the ideal material for use in high frequency electronic applications. It can be molded into exact shapes and machined to close tolerances. It resists great mechanical shock and extreme conditions of heat and humidity.

It has a very low power factor and dielectric loss. The Star product meets Government specifications.

After the war our great productive facilities will be at your disposal.

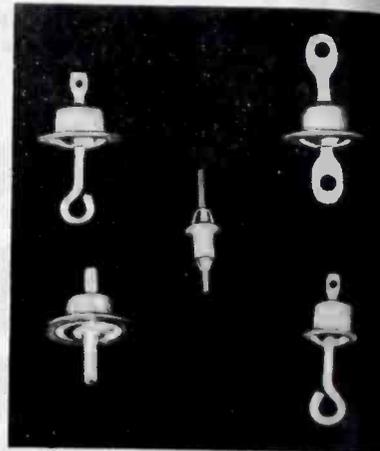
The
STAR
PORCELAIN COMPANY

ELECTRONICS DEPT.,

TRENTON, NEW JERSEY



chanical shock. They are completely free from absorption moisture and humidity, and the surface of the glass insulator provides maximum water-shedding properties. The electrode and cap are easily soldered, brazed



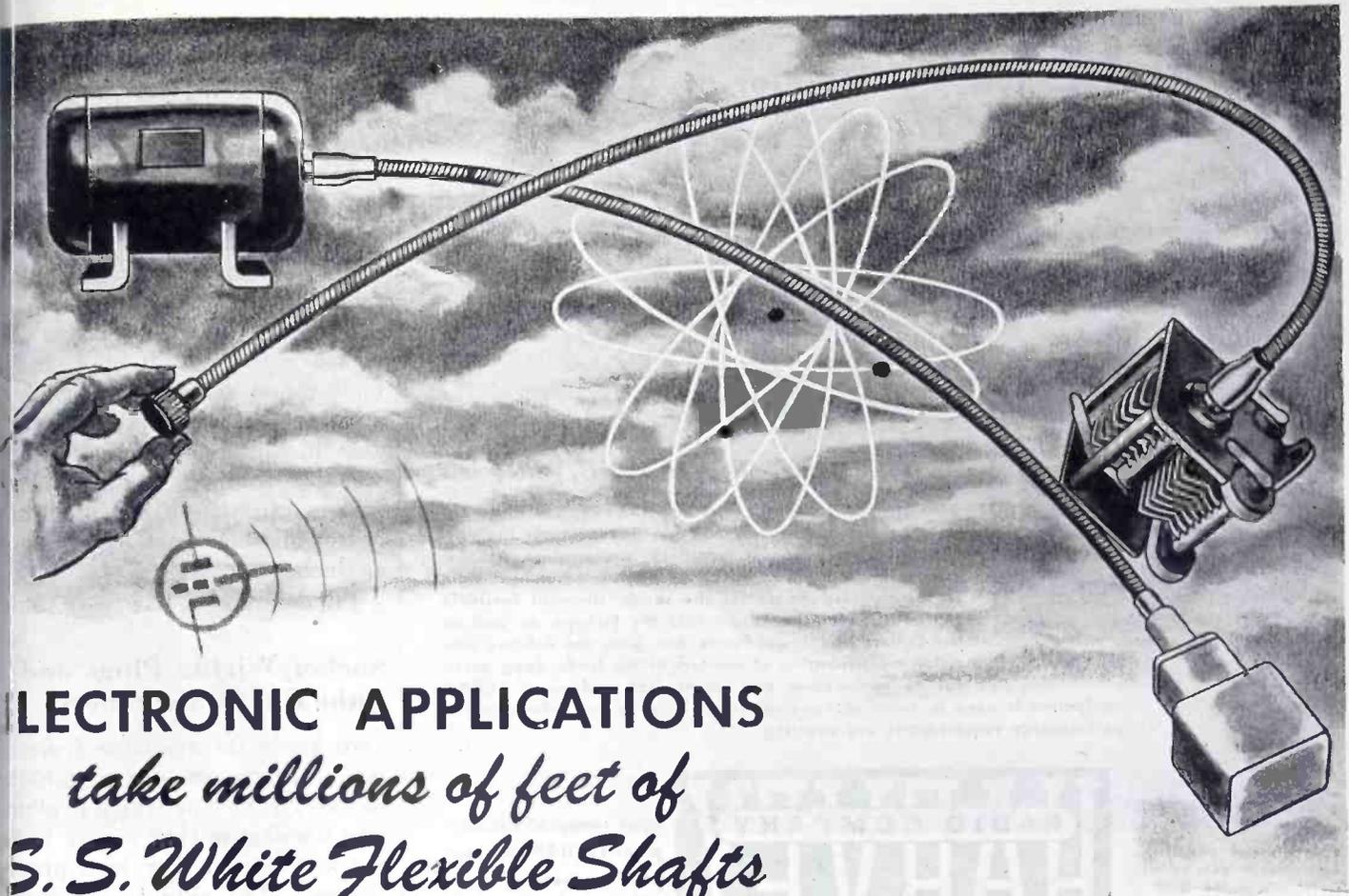
welded to a unit enclosure. Another feature claimed for these leads is that the use of Pyrex and Kovar form an absolutely gas and moisture-tight chemical bond, so that internal gas pressure may be maintained in units using them. This bond also minimizes the stress and strain of severe temperature changes.

Electrical Industries, Inc.,
Summer Ave., Newark 4, N. J.

Resin-Bonded Plywood Tubing

PLYTUBE IS THE NAME of a plywood tubing fabricated from thin veneers and a thermosetting synthetic resin. According to the manufacturer, laboratory tests show that weight for weight, Plytube will carry a heavier load than steel tubing. Urea Formaldehyde is the material used as its bonding agent, though Phenol may also be used. Veneers, selected for their overall strength, are built up so that stress





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This wide-scale acceptance and use of S. S. White Flexible Shafts by engineers throughout industry has been won and held through

- (1) Unmatched excellence in quality and performance.
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the "Royal Family" of pickups, cutters, jewel points

AUDAX, now available through HARVEY, distributor of fine radio and electronic equipment, represents the ultimate in professional recording accessories. AUDAX Pickups are made with the unique "relayed-flux" principle so largely responsible for the sharp, clear-cut facsimile reproduction of Microdyne. Into the Pickups, as well as the Cutters and Jewel Points, has gone the delicate precision craftsmanship of masters of the trade. Long noted for its engineering and mechanical perfection, AUDAX equipment is used in radio stations, recording studios and wherever the performance requirements are exacting.

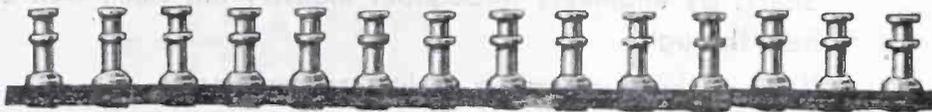
Free! PICK-UP FACTS!

Write today for this valuable booklet which contains the answers to most questions in the field of sound reproduction, written by Maximilian Weil, leading authority on the subject.



Upon receipt of suitable priority, HARVEY can promise you reasonably prompt deliveries of all AUDAX products.

ATTEN-SHUN!



C. T. C. TURRET TERMINAL LUGS are being ordered into action by more and more radio and electronics manufacturers. Here's why . . .



First — they're quick to apply. Just swage 'em to the boards and in a jiffy you have good, firm Turret Terminals.

Second — they save soldering time. Sufficient metal is used in their construction to provide strength, but not enough to draw heat and increase soldering time.

Third — quick delivery. Turret Terminal Lugs to meet a wide range of terminal board thicknesses are in stock.

Make C. T. C. TURRET TERMINAL LUGS your next order of the day. Write, phone or wire —

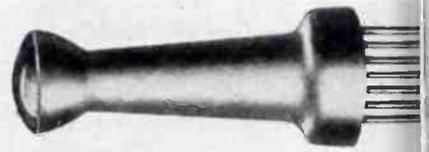
CAMBRIDGE Thermionic CORPORATION
439 CONCORD AVENUE · CAMBRIDGE 38, MASS.

and strain in any direction upon the total columnar grain fibers of the veneer layers. Plytube water, flame, splinter and rot proof. It has low electrical conductivity is dimensionally stable under extreme temperature ranges, and especially suitable for use in sub-zero weather. Among the many types of products made from Plytube are radio antenna masts which measure up to 90 ft high, and antennas and instrument covers for aircraft. The material is also available in any reasonable lengths of straight tubing. Inside diameters measure from 1/2 to 18 in. Wall thicknesses measure from 0.05 to 0.50 an inch.

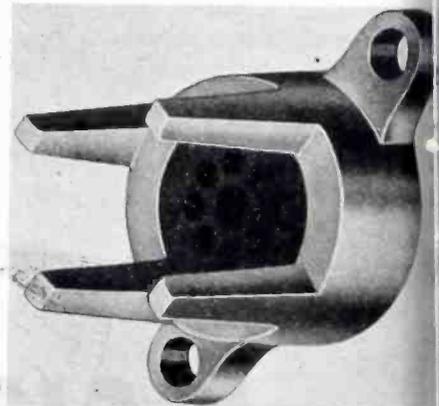
Plymold Corp., Lawrence, Mass.

Socket Wiring Plugs and Tube Pin Straighteners

TWO PRODUCTS available from the manufacturer include a miniature socket wiring plug which is plugged into a socket during wiring to keep the socket soldering lugs properly aligned. The plug is designed to minimize tube failure due to glaze



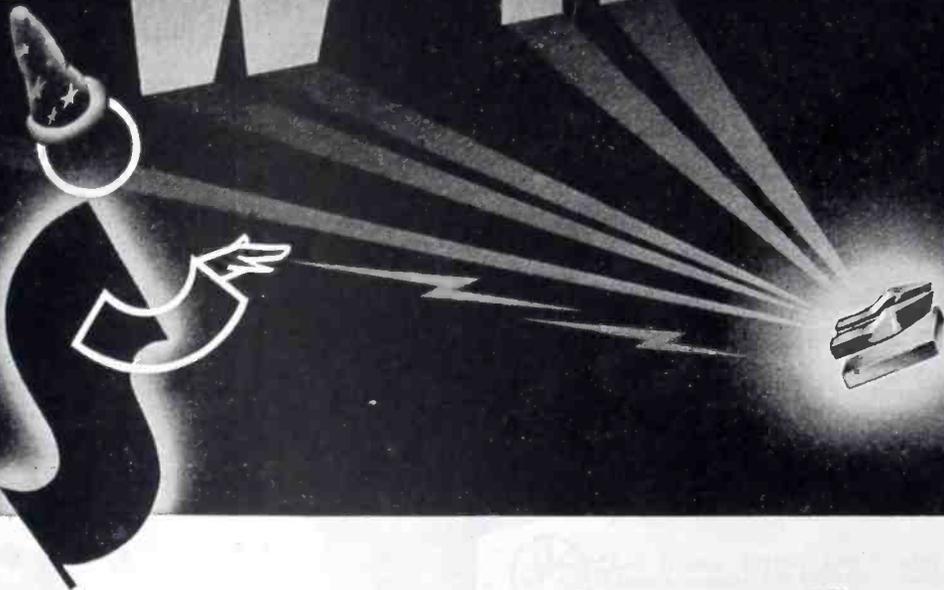
strains when tubes are plugged into sockets. The plug is made in one piece, of a zinc base alloy. The pins are made of stainless steel.



The tube pin straighteners for miniature tubes also have a zinc base alloy. The inserts are made of either hardened tool steel or of stainless steel.

Radio Accessory Div., Star Expansion Bolt Co., 147 Cedar St., New York 6, N. Y.

FW 41



AN IMPORTANT NEW *Silver-Tungsten* CONTACT DEVELOPMENT

STACKPOLE MOLDED CONTACT TYPES

Silver-Graphite

Silver-Copper-Graphite

Gold-Graphite

Silver-Nickel

Silver-Molybdenum

Silver-Tungsten

Silver-Nickel-
Molybdenum

Silver-Nickel-Tungsten

and dozens of
special alloys.

One-third smaller by volume and with half as many parts! That, in brief, is the story of a circuit breaker produced by a leading manufacturer, and made possible by use of silver-tungsten contacts utilizing the recently developed Stackpole "FW 41" formula.

Thanks to the efficiency of this new contact material, the interrupting capacity of the circuit breaker in *its new small size* has actually been increased from 10,000 amperes to 15,000 amperes. On special test, it has interrupted 21,000 amperes without apparent damage!

FW 41 is but one of many Stackpole contact developments of outstanding importance to electrical equipment manufacturers who realize that contact problems do not stay solved—that today's "best" may well be obsolete tomorrow.

Stackpole engineers welcome the opportunity to study your particular contact application in the light of recent improvements, making their recommendations and suggestions accordingly. The Stackpole contact laboratory includes ample facilities for making contact tests under actual operating conditions.

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

STACKPOLE

MOLDED METAL POWDER AND CARBON PRODUCTS

Wherever Precision Counts Most...



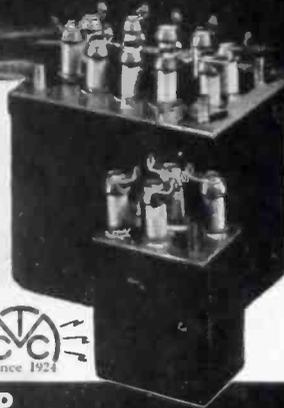
Products of "MERIT" are passing the test

Complying with the most exacting requirements for precision workmanship and durable construction, MERIT has established its ability to produce in quantity and deliver promptly—

Transformers • Coils • Reactors • Electrical Windings of All Types for Radio, Radar and Electronic Applications.

Today these dependable MERIT precision parts are secret weapons; tomorrow when they can be shown in detail as MERIT standard products you will want them in solving the problems of a new electronic era.

Illustrated: High Voltage Transformers A-2123 (small) and A-2124. Designed for high altitudes. Oil-filled and Hermetic sealed.



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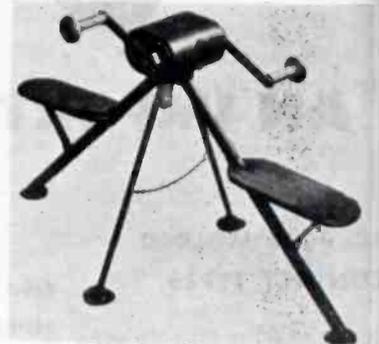
Railroad Dynamotors, and Hand Generators

THESE DYNAMOTORS are for use in communications systems for railroad use. They are designated in the Magmotor series, and utilize a permanent magnet instead of field coils. The units are rated 28 v d.c. input, and have an output of 350 watts at 100 ma. The dynamotors are equipped with precision-fitted ball



bearings to eliminate all end thrust and play occasioned by train motion and vibration.

This manufacturer also has available a new type hand-generator which has a maximum output of 10 watts. It is a permanent magnet

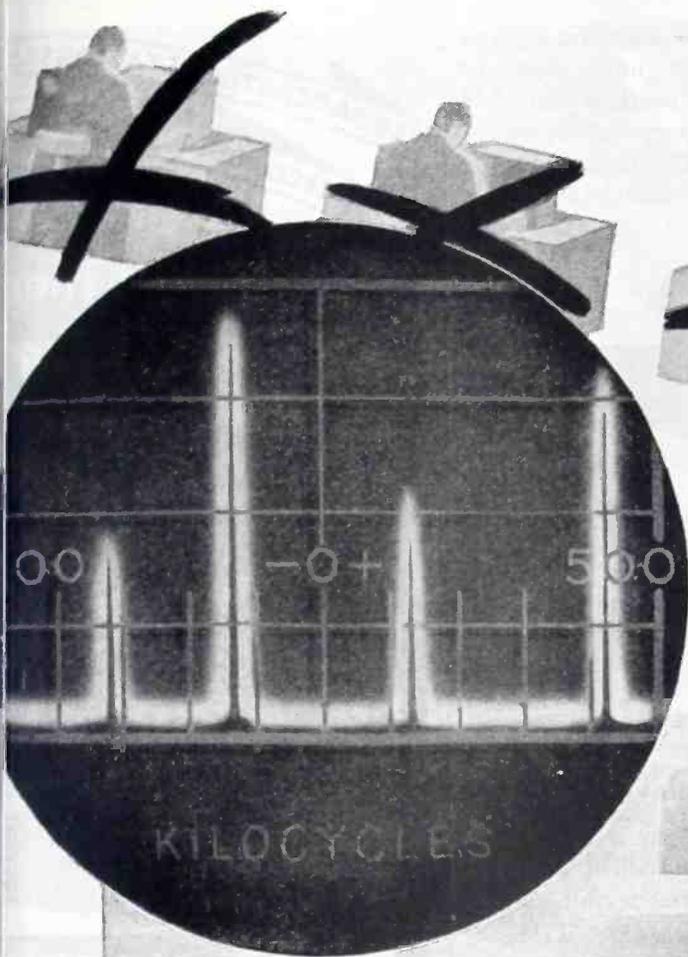


hand-generator which requires no outside electricity to operate. The cranks have been improved to prevent breakage due to operational leakage. A shatterproof unit enclosed with the meter, tells the operators when the output is being held to the correct value.

Carter Motor Corp., 1608 Milwaukee Ave., Chicago, Ill.

Radio Noise-Suppression Capacitor

COMPACT AND LIGHTWEIGHT Pyranol radio noise-suppression capacitors are especially designed to reduce noise voltage (particularly at higher frequencies) from generators, inverters, motors, and other equipment. The capacitors are of the thru-stud type with a terminal at each end. One line of a d-c or a-c power circuit can be fed through the unit, thereby reducing internal inductance and resistance, and in-



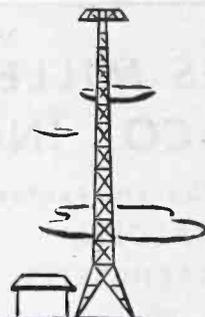
MONITOR with PANORAMIC

See a wide band- all at once

In the typical monitoring station—up to the present time—each received signal has required the active attendance of an operator and a receiver—the operator turning the dials ceaselessly and recording the signals on the air. With the aid of PANORAMIC RECEPTION, however, just one piece of equipment can do the work of many. Because PANORAMIC RECEPTION SHOWS ALL SIGNALS ON A GIVEN BAND OF THE RADIO FREQUENCY SPECTRUM SIMULTANEOUSLY, one operator can cover wider bands of the spectrum with more accuracy and less operator fatigue. Without dial manipulation, he can see immediately open channels and intermittent signals. Moreover, the patterns on the screen tell him the frequencies of the stations; their stability; their signal strength as they reach him; whether the station is AM, FM, or CW; and the type and extent of interference.

In monitoring, as in direction finding, navigation, production, and laboratory procedure, PANORAMIC RECEPTION is becoming an indispensable timesaver. Its unique capabilities will offer new solutions to your industrial and laboratory problems. Allow one of our engineers to explain how PANORAMIC RECEPTION may be used to your best advantage.

Now and interesting booklet "From One Ham to Another." Available on request. Fully illustrated.



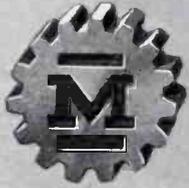
PANORAMIC



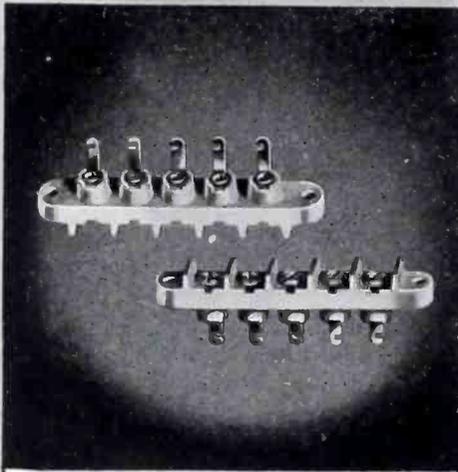
RADIO CORPORATION

242-250 WEST 55TH ST. New York 19, N. Y.

Designed for



Application



**The No. 37105
Steatite Terminal Strip**

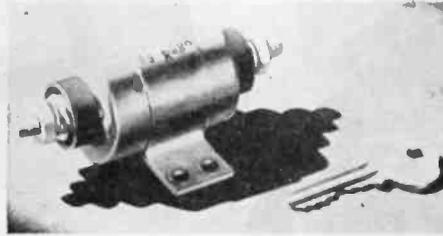
• Another exclusive Millen "Designed for Application" product is the No. 37105 Steatite five-terminal strip. Lugs soldered as well as mechanically attached to floating screw machine units. Easy to mount with series of round holes for integral chassis bushings. Ideal answer to the "tropicalization" problem.

**JAMES MILLEN
MFG. CO., INC.**

MAIN OFFICE AND FACTORY
**MALDEN
MASSACHUSETTS**



creasing filter efficiency for a given capacitance. The units can be mounted in any position and will operate over a temperature range of ± 50 deg C. The capacitors are rated 0-100 amp, 250 v maximum



a.c. or d.c., 0.55 microfarad. They are designed to meet exacting vibration tests required by AAF specifications. Bulletin GEA-4308 contains complete information.

General Electric Co., Schenectady, N. Y.

Time Delay Relays

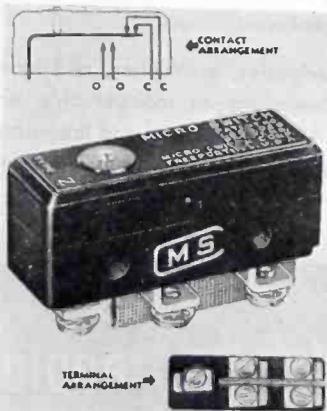
IN ORDER TO OPEN the main control circuit in case an added overload period exceeds a predetermined time interval on a line, Type TD8 accumulative time-delay relay may be used to add the time interval of momentary overload surges occurring in quick succession.

Also available is Type TD5 time-delay relay which will withstand momentary shocks without affecting the switch circuit. It has a cam-operated switch mechanism.

The R. W. Cramer Co., Inc., Centerbrook, Conn.

Split-Contact Switches

THESE DOUBLE-THROW, split-contact switches may be used to switch an operation from a d-c control to an a-c control. Two sets of contacts are mechanically interlinked but electrically isolated. Transfer action is a matter of a few milliseconds.



BROADCASTING STATIONS!
RECORDING STUDIOS!
SCHOOLS!

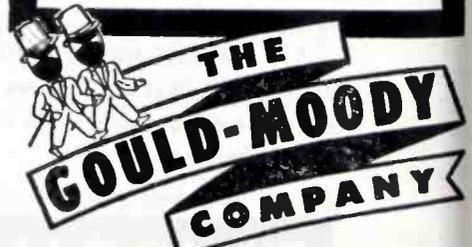
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Without Delay!*



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"Black Seal"
GLASS BASE
INSTANTANEOUS
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The tributes paid to "Black Seal" discs by many leading engineers have been earned by distinguished service on the turntable. Your ears will recognize the difference in quality of reproduction, and the longer play-back life will prove the superiority of "Black Seal" construction. Choice of two weights—thin, flexible, interchangeable with aluminum, or medium weight—both with four holes.

An AA-2X rating is automatically available to broadcasting stations, recording studios and schools. Enclosure of your priority rating will facilitate delivery Old Aluminum Blanks Recoated with "Black Seal" Formula on Short Notice



RECORDING BLANK DIVISION
395 BROADWAY • NEW YORK 13, N. Y.

EXPORT DEPT. ROYAL NATIONAL COMPANY, INC.
87 BROAD STREET, N. Y.



One battleship needs as many telephones as a city of 10,000

When U. S. warships go into action, telephone equipment transmits orders instantly, clearly.

For the huge battleship "Wisconsin," Western Electric supplied two separate telephone systems using equipment designed by Bell Telephone Laboratories.

1. *Sound powered telephone system* —with 2200 instruments connecting all battle stations. These bat-

tle phones operate on current generated by *the speaker's voice*, so damage to the ship's electrical power supply cannot interrupt communications.

2. *Battle announcing system* — with 20 transmitter stations and over 300 loudspeakers which broadcast orders in a giant voice.

All this for just one battleship! Aircraft carriers, cruisers, destroy-

ers, submarines, merchant ships too must have telephone equipment.

Today Western Electric — long a pioneer and leader in the field of sound-transmission apparatus — is the nation's largest producer of electronic and communications equipment to aid our armed forces at sea, on land and in the air.

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New **ATLAS Little GIANT**

Model DR-12

Versatile is the word for Atlas Sound's latest creation, the DR-12 Little Giant (Bell diameter 7 in. Overall length 7½ in.) Its construction gives equally gratifying service when used for marine application, factory, police and other communications... a design that has proven itself more than equal to War's rigorous demands.



Write for detailed description.

ATLAS SOUND

CORPORATION

1449 39th Street

Brooklyn, New York

The switches may also be used to control four isolated circuits by pairs, eliminating the use of relays and other isolating means from the circuit. The switches themselves have two contacts on both the normally open and normally closed side as shown in the accompanying illustration. Outside dimensions are the same as the manufacturer's basic SP switch. Catalog No. BZ-3YT describes pin-plunger types. Types D and S plunger designs are also available.

Micro Switch Corp., Freeport, Ill.

Capacitor Motors

THESE MOTORS (Type J-70) may be used for driving blowers in high ambient temperatures and for powering small control devices of all types. Units are rated 60 cycles, 115 v, single phase, 3400 rpm. They have a low temperature rise. Each



unit weighs 3 lb and measures 3½ in. in diameter, overall length 3½ in., shaft diameter ⅝ in. Also available are motors which will deliver 1/25 hp and can be wound for 2 or 3 phase. Higher speeds and hp for 400-cycle applications are available.

Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.

Flat Keying Relay

THE CHATTER HAS BEEN removed from Series 200 relays by a new improvement which consists of an energy-absorbing material, sealed within a contact-carrying cage. The compound used is not affected by age, oil or moisture. These improved relays have no bounce and will key up to 150 words per min, or 60 impulses per second. Input is 50 milliwatts. The armature of the units is mica insulated and is suitable for keying a 50-Mc r-f signal. Contacts will carry up to 2 amp.

Kurman Electric Co., 35-18 37th St., Long Island City, N. Y.

Delco Radio Products Mean Dependability



All over the world Delco Radio products are in useful service. They prove daily that the name Delco Radio means dependability . . . dependable designs developed with care and imagination; dependable products built with craftsmanship and skill. In radio and electronic equipment, the name Delco Radio stands for engineering vision—manufacturing precision.

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Delco Radio
DIVISION OF
GENERAL MOTORS



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**A New dielectric
thermosetting
Liquid Plastic
with many unique
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NO VACUUM IMPREGNATION

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430 F—FUNGICIDE... a non-volatile, non-toxic coating, resistant to Fungi and Mold growth.

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LAMINATIONS ETC.

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Thermolex **LIQUID
PLASTICS CO.**

**ELIZABETH & NEPPERHAN AVES.
YONKERS 3, N. Y.**

Potentiometers

THIS MANUFACTURER announces that they will again be able to supply potentiometers (Type N-103) made of non-substitute materials. Wartime restrictions changed the specifications for control shafts from aluminum to steel in standard sizes of 2½ in. lengths, and now the manufacturer is reverting again to aluminum shafts extending 3 in. from the end of a ¾ in. bushing. Universal fluted mills which simplify filing and allow for all types of knobs will be used.

Centralab, 900 E. Keefe Ave., Milwaukee 1, Wis.

Rubber Latex Insulation

NUBUN IS THE NAME of a new synthetic rubber latex insulation for power and communication cable. It has improved electrical and physical characteristics for applications where replacement, servicing and space are important factors. Other features claimed for it include greater resistance to destructive forces, flexibility, impermeability to water and laminated construction. Nubun insulation is made from a special modification of buna S synthetic rubber.

United States Rubber Co. Rockefeller Center, New York, N. Y.

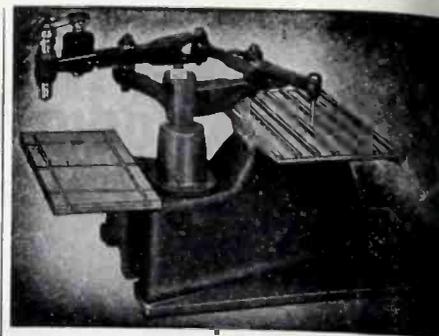
803 Pentode Tube

MASS PRODUCTION of Type 803 pentode tube for military and priority orders is now being done by Taylor Tubes, 2312 Wabansia Ave., Chicago, Ill.

Phenolic Insulating Material

RESINOX No. 7934 is a new phenolic molding compound which may be used as an insulating medium in high-frequency apparatus. It has a low dielectric constant and power factor, low water and moisture absorption (0.03 percent under ASTM tests which call for 24-hour water immersion) and relatively high heat resistance. This new material is mica-filled and is based on a newly developed phenol - formaldehyde resin.

Monsanto Chemical Co., St. Louis 4, Mo.



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*Accurate Engraving
with Unskilled Operators*

Unskilled operators will profile or accurately reproduce in smooth lines any design, number, letter, emblem, signature; on iron, brass, copper, aluminum, soft steels and all plastics. Here are some of its other uses . . .

- Drills a series of holes, or profiles small parts.
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For complete information on this and other models and prices write Dept. K.

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NEON XENON MIXTURES**



**RARE GASES
AND MIXTURES**

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Scientific uses for LINDE rare gases include—

1. The study of electrical discharges.
2. Work with rectifying and stroboscopic devices.
3. Metallurgical research.
4. Work with inert atmospheres, where heat conduction must be increased or decreased.

Many standard mixtures are available. Special mixtures for experimental purposes can be supplied upon request.

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In Canada: Dominion Oxygen Company, Ltd., Toronto

CHECK TRANSMITTER FREQUENCY IN LESS THAN A MINUTE



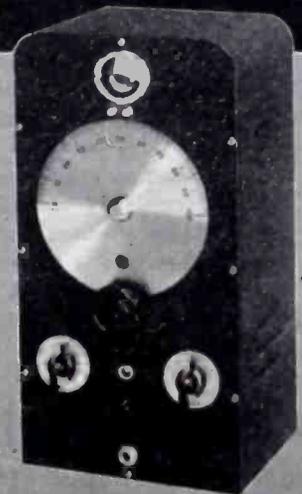
THE BROWNING FREQUENCY METER, used by police and other emergency radio facilities for the past five years, is still the best meter for such services — because it was specifically designed for them. The design, which permits determination of any five frequencies from 1.5 to 120 Mc., makes for simplicity of operation which requires less than one minute to check one frequency. All Browning development work aims at specific, rather than broad, uses. Thus, all Browning equipment is best for its particular job. Furthermore, Browning Laboratory facilities are available for study and solution of your own, specific electronic engineering problems.

Write for data.

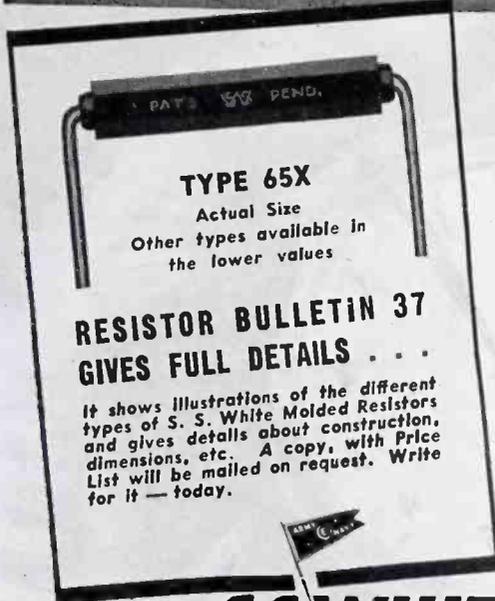


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**LABORATORIES, INCORPORATED
WINCHESTER, MASSACHUSETTS**



S.S. White **MOLDED RESISTORS** The "All-Weather" Resistors



TYPE 65X
Actual Size
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the lower values

**RESISTOR BULLETIN 37
GIVES FULL DETAILS . . .**

It shows illustrations of the different types of S. S. White Molded Resistors and gives details about construction, dimensions, etc. A copy, with Price List will be mailed on request. Write for it — today.

WIDELY FAVORED because of **NOISELESS** operation, **DURABILITY** and fine **PERFORMANCE** in all climates . . .

STANDARD RANGE
1000 ohms to 10 megohms
NOISE TESTED

At slight additional cost, resistors in the Standard Range are supplied with each resistor noise tested to the following standard: "For the complete audio frequency range, resistors shall have less noise than corresponds to a change of resistance of 1 part in 1,000,000."

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THE S. S. WHITE DENTAL MFG. CO. DEPT. R, 10 EAST 40TH ST., NEW YORK 16, N. Y.
FLEXIBLE SHAFTS AIRCRAFT ACCESSORIES
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★ Rogan's exclusive plastic branding process has been employed extensively to speed production of many important war plastics. The bakelite Azimuth Dial illustrated, is one example

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However, wartime demands for this service in some ordnance plants, have required the application on their own premises. So, Rogan engineers have arranged a method whereby anyone can do his own branding on plastics right in his own plant. Rogan will engineer each job completely and build all the necessary tools. Will provide clear, simple instructions that will permit anyone to do the job expertly. All you need do is to send us blue prints and other specific data, and we'll give you a quick cost and time estimate.

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NEW BOOKS

Automatic Control Engineering

By ED SINCLAIR SMITH, research engineer, Eclipse-Pioneer Division Bendix Aviation Corporation. McGraw-Hill Book Co., New York. 300 pages, price \$4.00.

THE AUTHOR has included the material necessary to enable anyone who has studied engineering to understand and apply the principles of control to any application or process. Considerable attention is given to terminology. Definitions are presented as adopted by the A.S.M. Division of Industrial Instruments and Regulators, German standards and the 1941 Temperature Symposium.

To orient the reader, principles are enumerated which underlie the characteristics of meters and controllers, lags in plants, main components of controllers, steady-state performance, transient performance, and the application of regulators to plants. Although only a few pages deal specifically with electronic control principles, much of the non-electronic information is vitally essential to engineers seeking electronic solutions to control problems.—J.K.

Beloved Scientist, life of Elihu Thomson

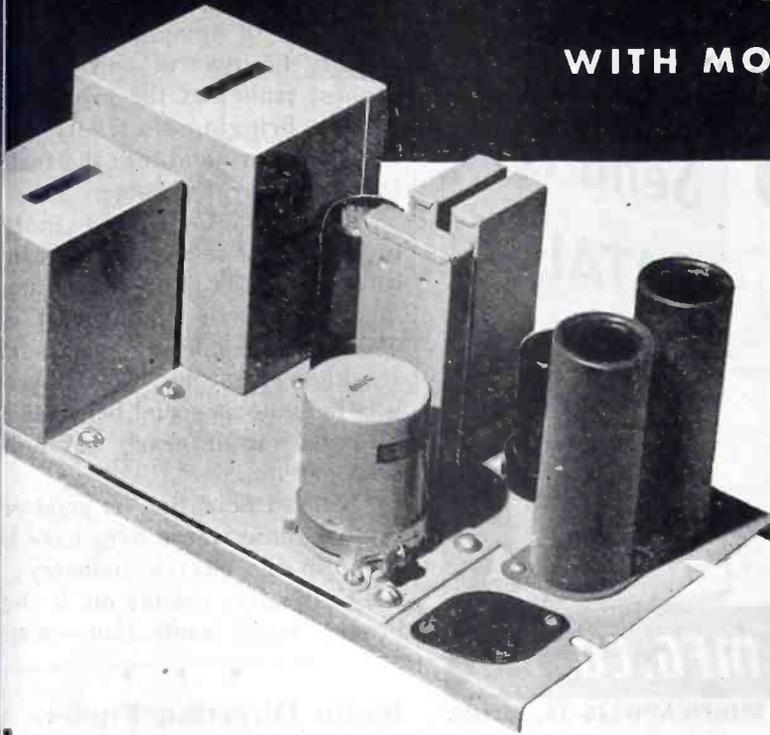
By DAVID O. WOODBURY, Whittle House, New York. 1944. Price \$3.50

ALTHOUGH THE DIVIDING line between a scientist and an inventor is sometimes narrow, there can be no doubt about Elihu Thomson's place in the world—he was one of our great scientists. This story of David Woodbury's is not only a biography of a beloved scientist with an eager, creative mind which respected other minds; it is the story of the electric light, the arc lamp, the transformer, of dynamos and motors, electric welding, metering of electric current and voltage and power, of voltage regulators. For Elihu Thomson lived in an age of golden opportunity, as a contemporary (and often a competitor) of Edison, Brush, Bell, Westinghouse, Tesla, Röntgen, Marconi, Sprague, Lodge, Pupin. The book is also

102 SERIES

Amplifiers

WITH MOUNTING ACCESSORIES



TYPE 102-A—Two stage—Fixed gain 55 db. Input impedance 30, 250 or 600 ohms; output impedance 600 ohms. Frequency response 30-16,000 Cycles \pm .5 db. Power output + 26 VU with less than 1% harmonic content. Requires external power supply 275 Volts DC 30 M.A., and 6.3 Volts AC .75 Amps. When a 102 Series Amplifier is used in conjunction with a 101 Series Amplifier, the latter is capable of supplying the necessary power.

The 102 Series Amplifiers consist of four different amplifiers available simply by changing a small input panel on the master chassis. Except for the input panel, they all have the same transmission characteristics. Designed for the highest type audio service, they will meet frequency modulation requirements as to frequency response, power output vs. distortion and noise level.

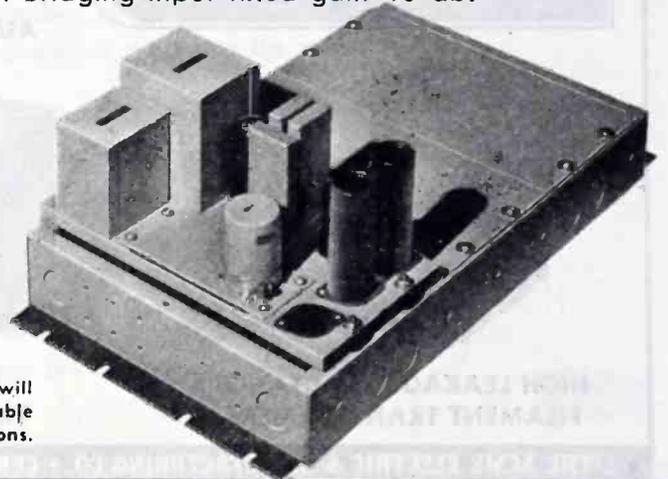
TYPE 102-A as illustrated and described above.

TYPE 102-B—Three stage—Gain 95 db. In-

tended for high grade public address installations. Input stage electronic mixing.

TYPE 102-C—Three stage—Fixed gain 95 db.

TYPE 102-D—Two stage—Input impedance 600 ohms and bridging. Fixed gain 600 ohm input 61 db. Bridging input fixed gain 45 db.



The 3A Mounting Frame, requiring 10½ inches rack space, will accommodate up to THREE 102 Series Amplifiers and is suitable for wall mounting cabinet or rack and panel installations.

The Langevin Company

INCORPORATED

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NEW YORK

37 W. 65 St., 23

SAN FRANCISCO

1050 Howard St., 3

LOS ANGELES

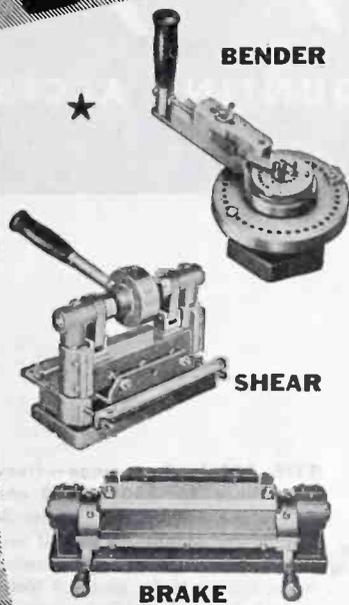
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MAN
HOURS
AND
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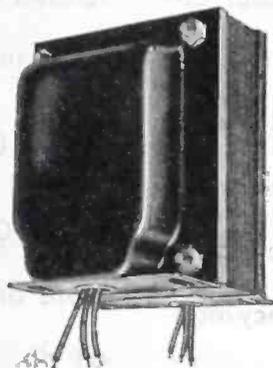
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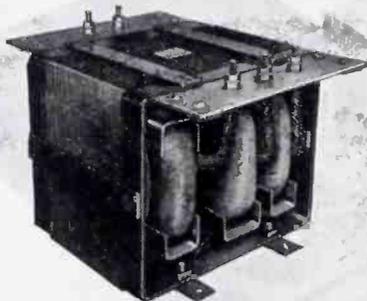
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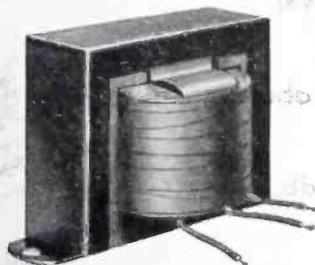
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Acme  Electric

the story of the foundation of the General Electric Company and its early days; of Charles Coffin and E. W. Rice, Jr.

The book is also the story of many patent dogfights; and of the mercenary who seemed bent on making the days of the scientist-inventor Thomson unhappy. It is the story of imagination and ingenuity brought to service on the highest plane; of the great adventure of bringing electricity out of the laboratory and into the factory, the street car, the home.

Elihu Thomson's place in those great days is secure; he was interested in theory as well as practice; he worked with the utmost care, weighing, pondering, measuring. He knew what he was doing; he was humane; a social being as well as a possessor of nearly seven hundred patents.

"Beloved Scientist" is good reading for those whose lives have been spent in the electric industry; for the youngsters coming on, it should provide much inspiration.—K.H.

Radio Direction Finders

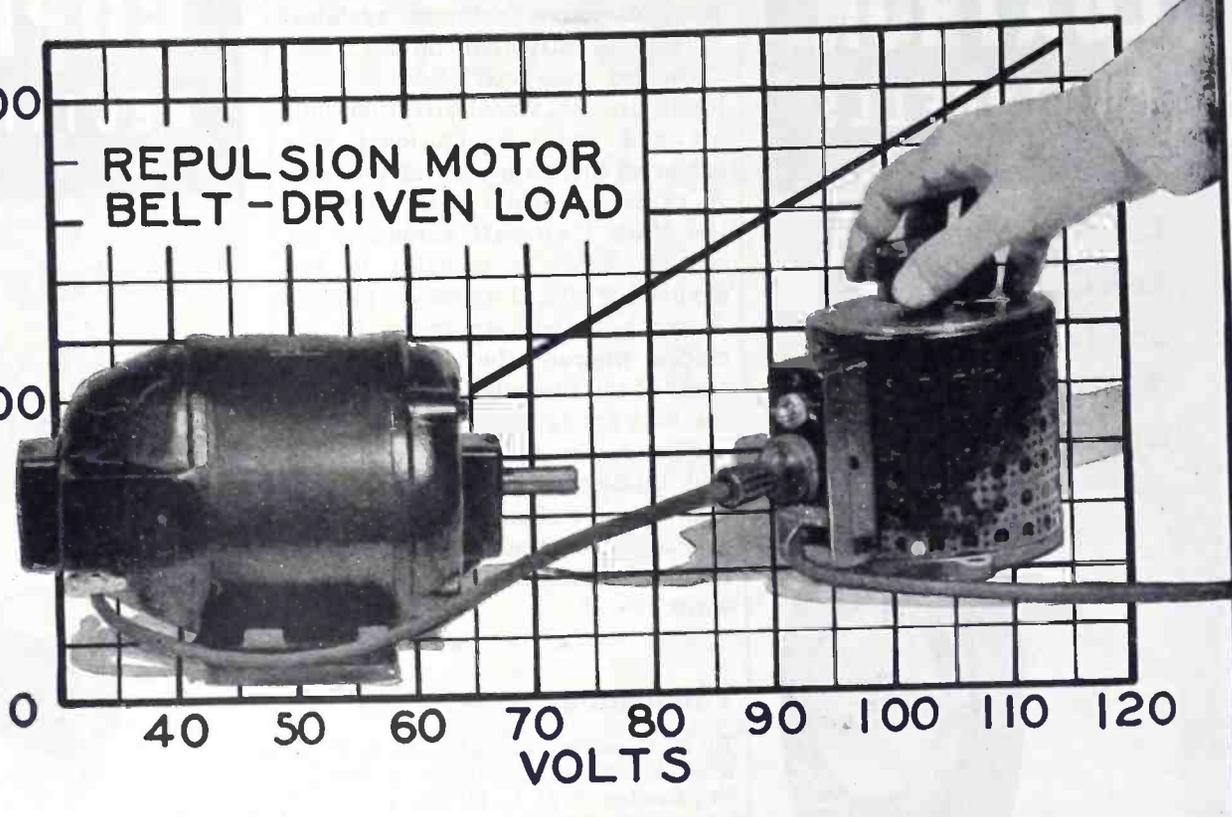
By DONALD S. BOND, McGraw-Hill Book Co., New York 18, N. Y. 1944
287 pages, 162 illustrations, price \$3.00.

THIS BOOK, the third in the McGraw-Hill communication series edited by Beverly Dudley, is the first published in this country exclusively on the subject of direction finders. The author, an experienced engineer in the field of direction finder design, writes specifically for electrical engineers and others having a broad engineering training and little if any experience in this particular specialized field. The author has made available in usable and organized form as much of the existing technical data on the development of direction finders as could be crammed into a volume whose size is not so great as to discourage a busy engineer in need of information. Application of the subject matter to specific problems is illustrated by means of examples worked out in the text.

The book starts out with a chapter giving general information and standard test procedures on direction finders. These data are tied in with data usually taken in making performance measurements on



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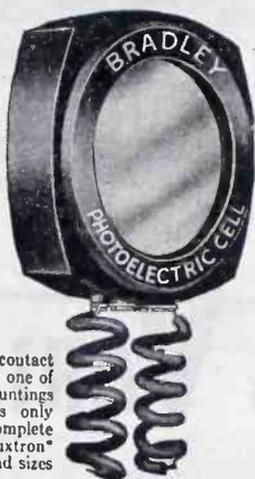
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communications receivers, A goodly part of the material is in handbook form. Chapters on wave propagation, directive antenna systems, aural null direction finders, performance characteristics of loop input circuits, visual direction finders and radio navigational aids comprise the main body of the text. A rather complete description of the Mark I aircraft automatic direction finder is included in the chapter on visual direction finders. A mathematical appendix is included wherein the derivation of some of the formulas not derived in the text are to be found.

The many footnote references and bibliographies at the end of each chapter should facilitate further study on the part of those in need of additional information.—W.O.S.

• • •

Foundations of Wireless

By M. G. SCROGGIE. Published by Iliffe & Sons, Ltd., Dorset House, Stamford St., London, S. E. 1., 4th ed., 1943, 358 pages, price 7s, 6d.

A COMPLETE NEW EDITION of a well-known British basic textbook on radio.

Twenty-one chapters are provided and a simple listing of their headings indicates the logical treatment of the subject: an outline of broadcasting, elementary electrical notions, capacitance and inductance, alternating currents, a-c circuits, the tuned circuit, the triode valve, oscillation, the transmitter, detection, the single-valve receiver; reaction, radio-frequency amplification; screened valves, selectivity in the r-f amplifier, audio frequency and output stages, designing a receiver, the superheterodyne and its frequency changer, tuning circuits in the i-f amplifier, automatic controls, power supplies, radiation and aerials, and transmission lines. The preface explains mathematical formulas and symbols for readers having no technical training.

Although most of the terms used are standard for both British and American practice, there are some few variations that would be unfamiliar to readers on this side of the Atlantic. To overcome this there is a two-page appendix that lists terms and their equivalents, with distinctively American expressions printed in italics.—K.S.P.

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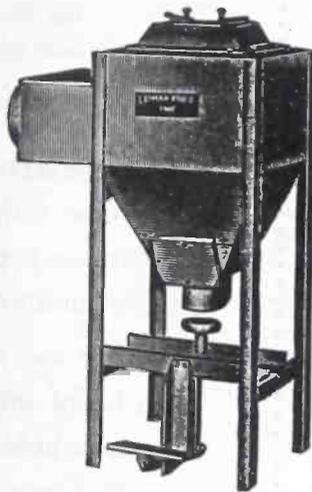


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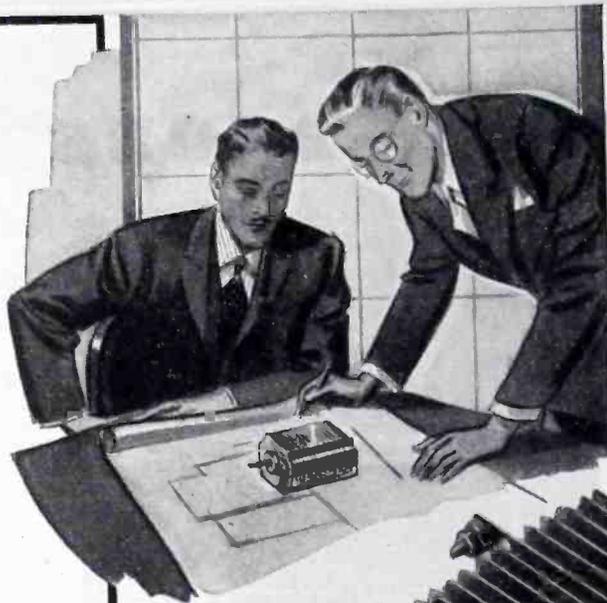
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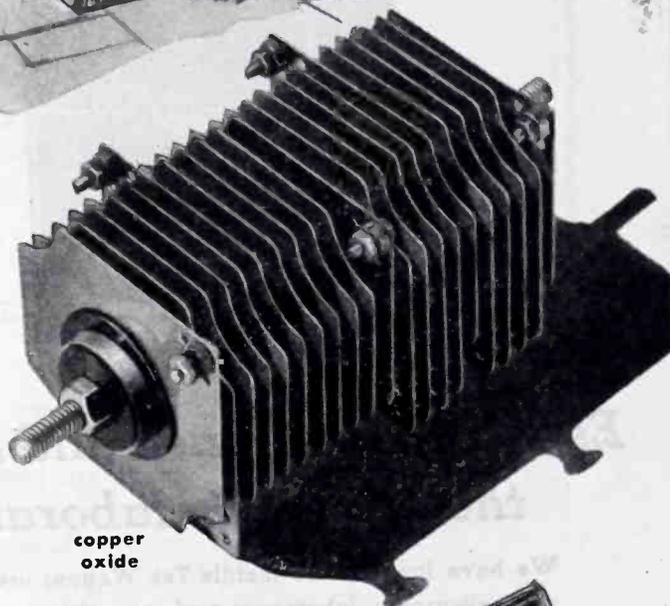
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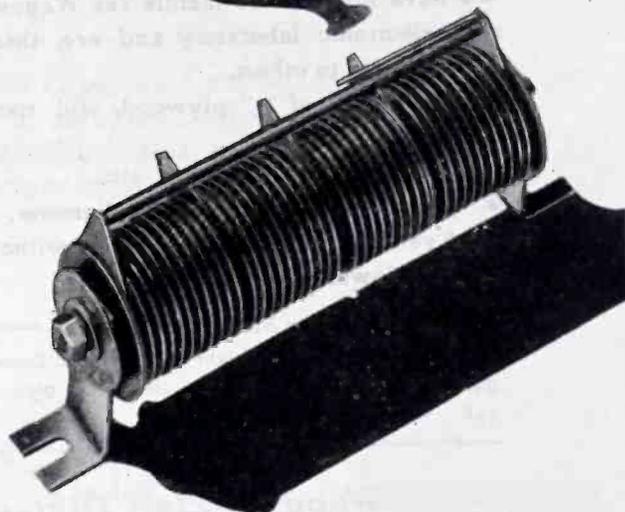
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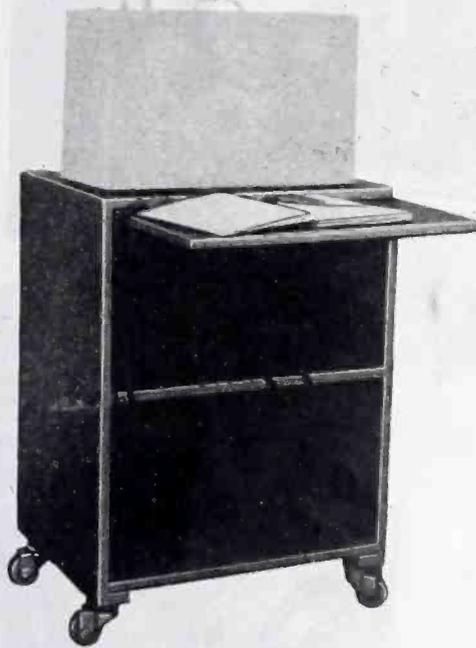


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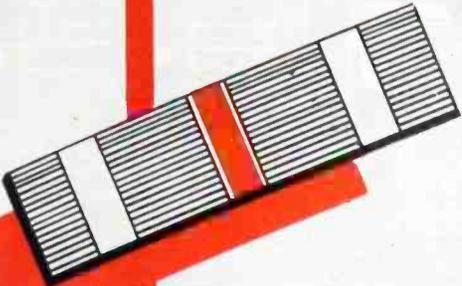
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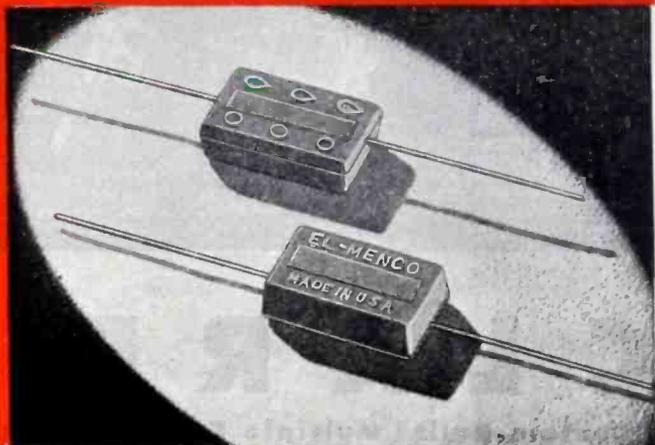
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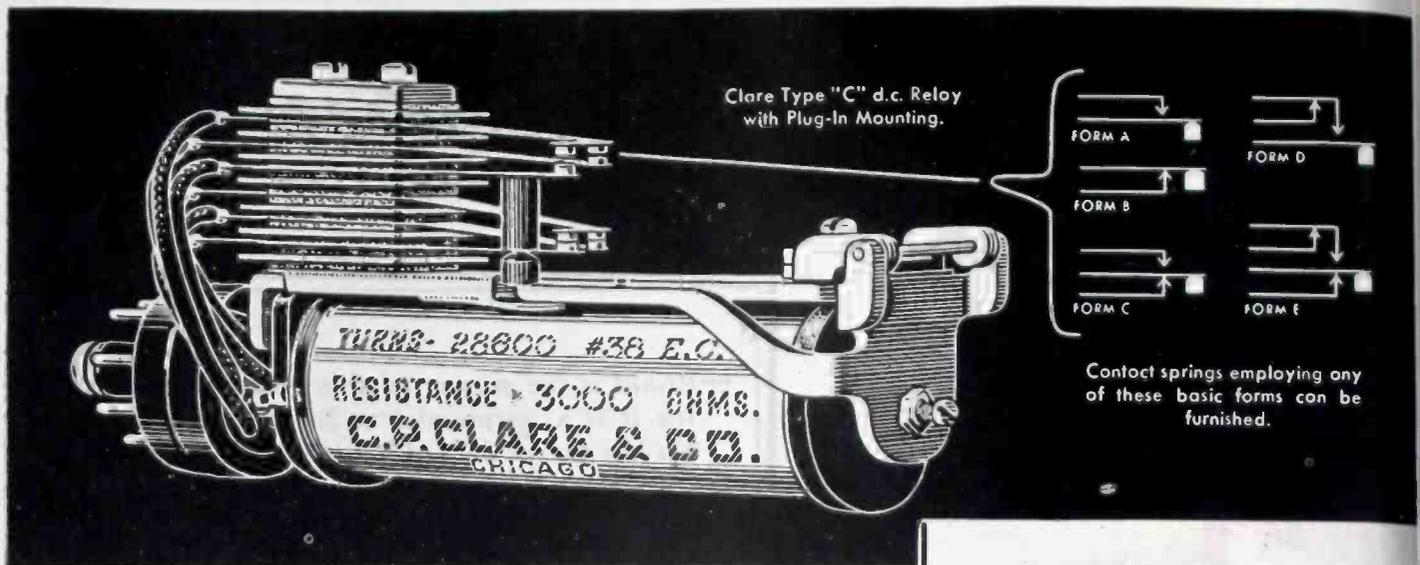
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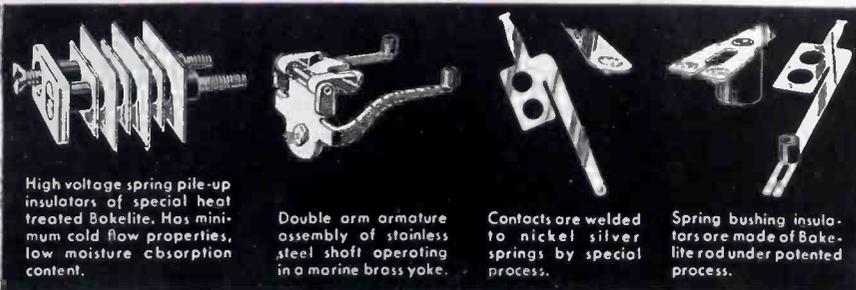
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Contacts are welded to nickel silver springs by special process.

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3

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This consists of contact springs and insulators assembled to the heelpiece. The assembly is clamped under hydraulic pressure and special high-tensile screws are fastened with a power driver to insure a rigid assembly.

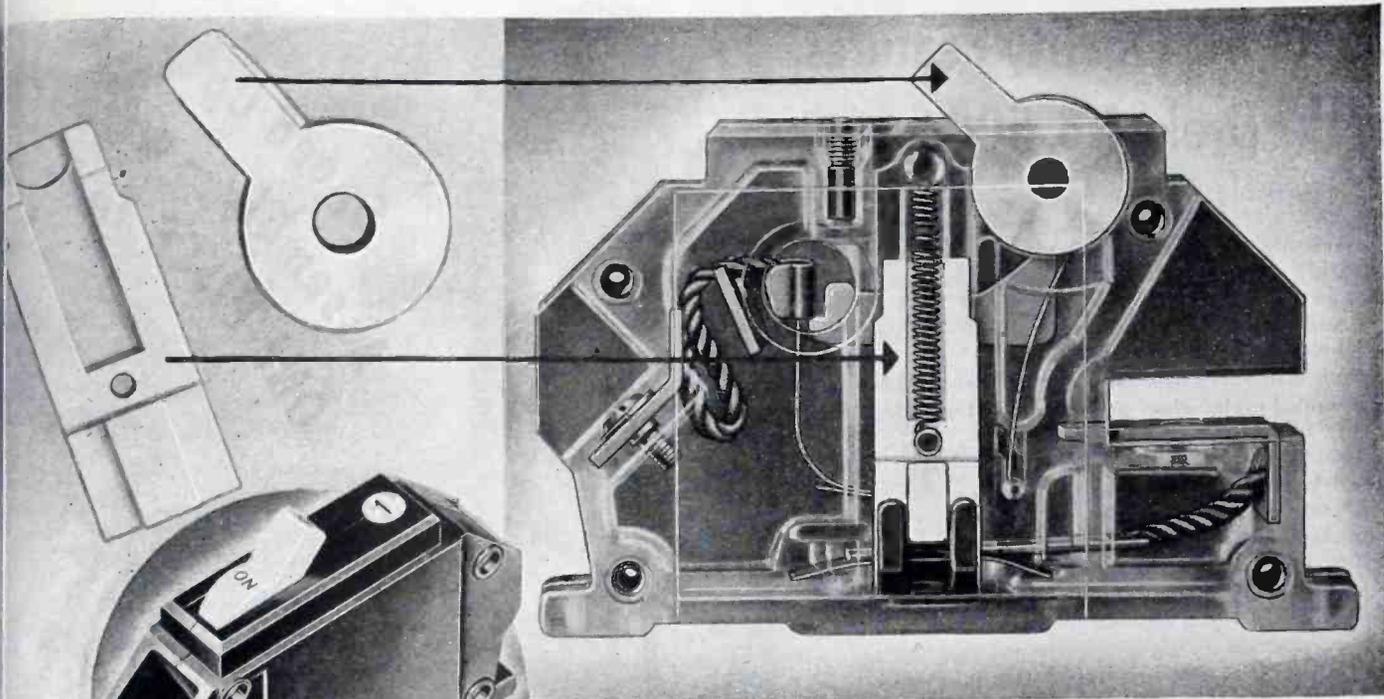
4

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Contacts of various materials and sizes are available. These may be of precious metals or alloys, such as silver, palladium-irridium, tungsten and elkonium. Various types can be incorporated in one relay.

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"Custom-Built" Multiple Contact Relays for Electrical, Electronic and Industrial Use



Product of Frank Adam Electric Co., St. Louis, Mo.

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- 2. Smooth surface, eye-catching, warm to touch.
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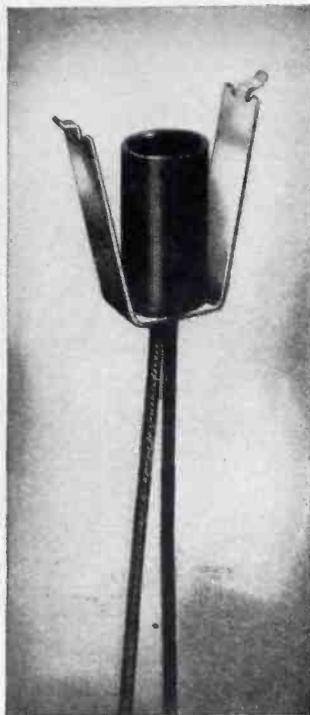
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Tongue, barrel, and insulation gripping ears are formed from a single piece of fine grain, specially rolled, pure electrolytic copper of the highest conductivity obtainable. Entire inside of barrel is serrated, to grip the full circumference of the wire.

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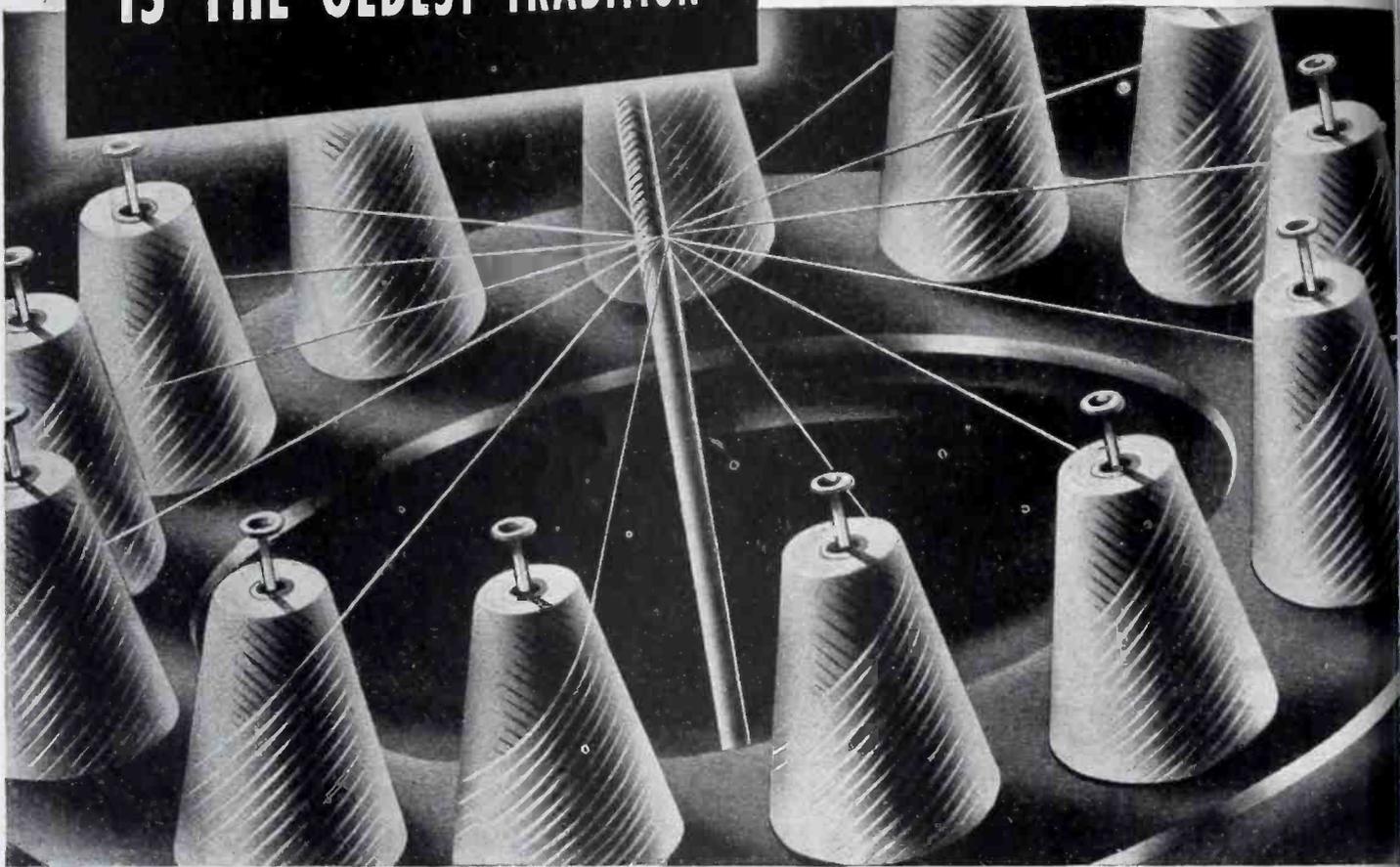
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the equipment which The Ansonia Electrical Company produces comes from the Naugatuck Valley, where *looking ahead* is the oldest tradition!

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they did not exist. We look forward to providing the same abilities in peace. Not merely because of specialized mechanical equipment, but because meeting new needs in our field efficiently and economically has been and is our real business, we anticipate meeting similar and *more* difficult peacetime industrial problems involving electrical cables.

ANKOSEAL multi-conductor insulated cables are among the most promising of Ansonia war-proven developments. If you have, or expect to have a use for electrical cables—
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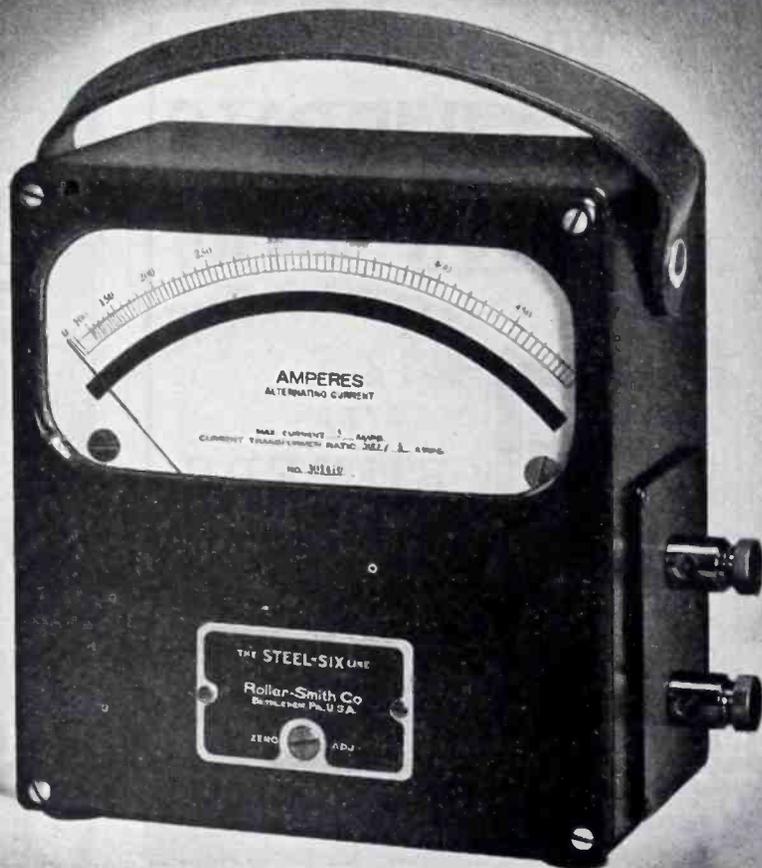
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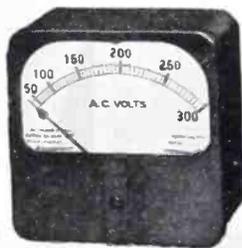


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Included in the broad range of electrical instruments that bear the R-S mark are the 3.5" miniature panel instruments shown below. These are built in commercial types and to A.S.A. War Standard C 39.2-1944. Other R-S instruments include switchboard and portable types to meet practically every industrial, power and laboratory need. Let us quote prices and deliveries on your instrument requirements.



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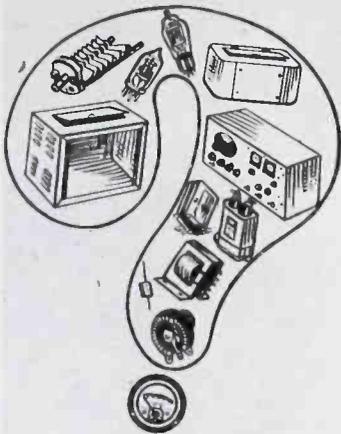


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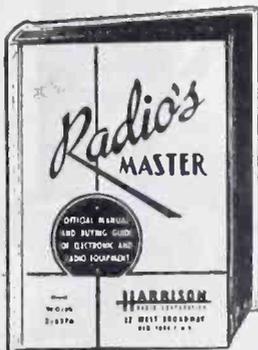
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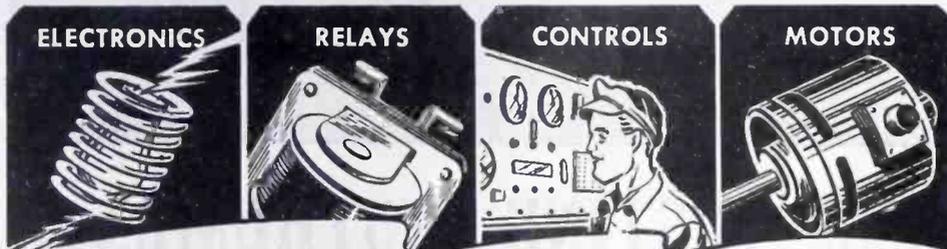
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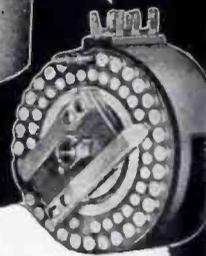


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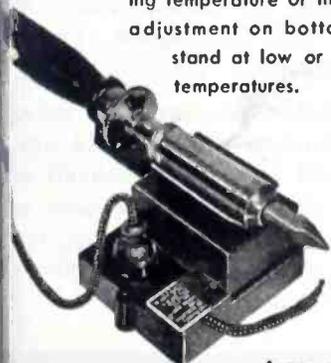


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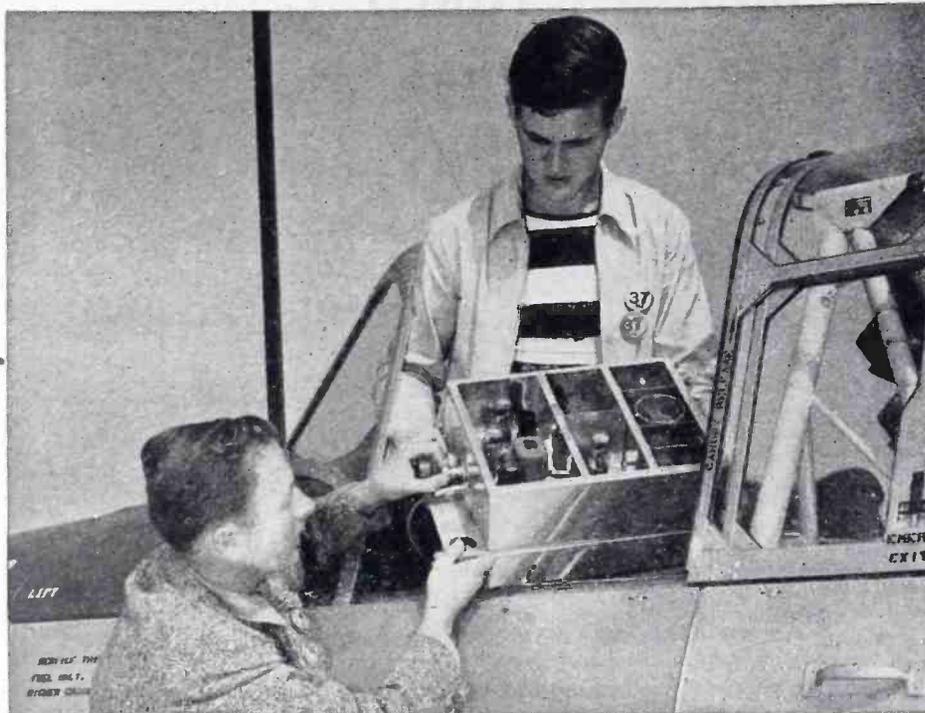


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106

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THIS MONTH—AUTOMATIC FLIGHT RECORDER



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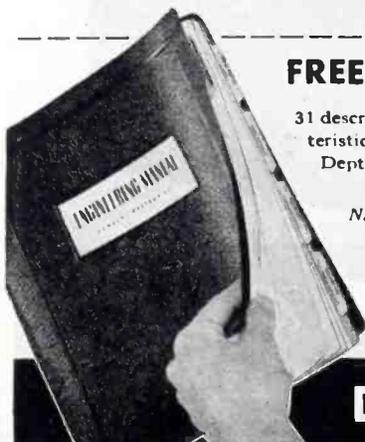
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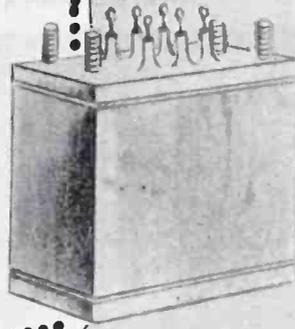
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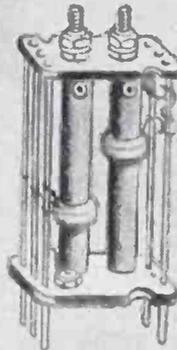


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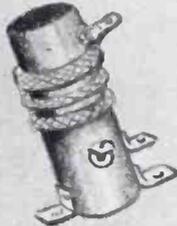
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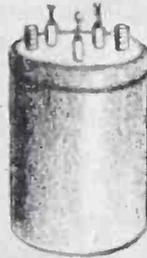
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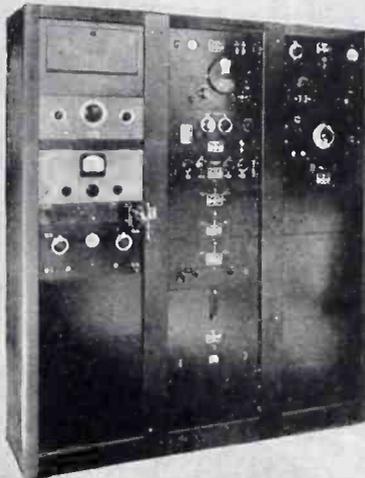


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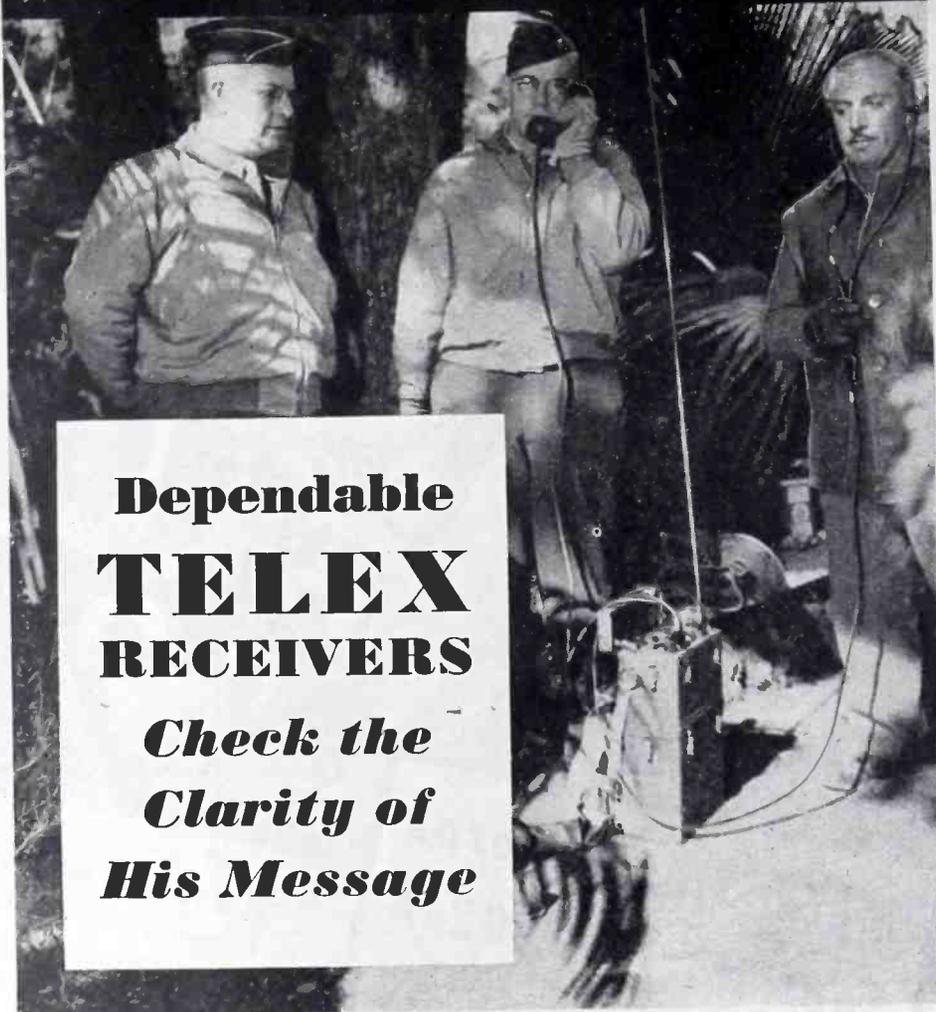
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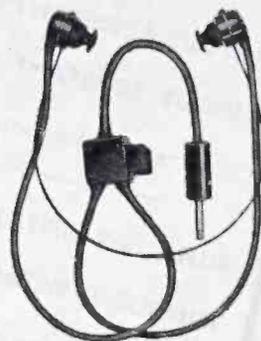
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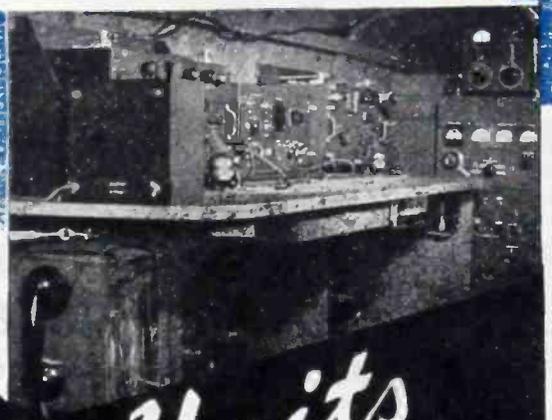
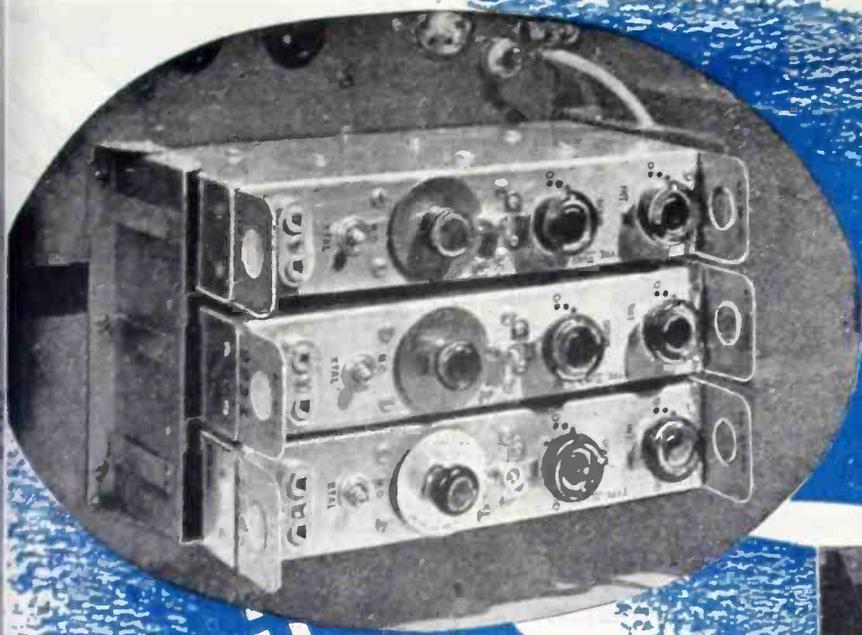
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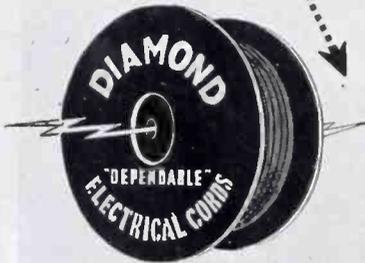
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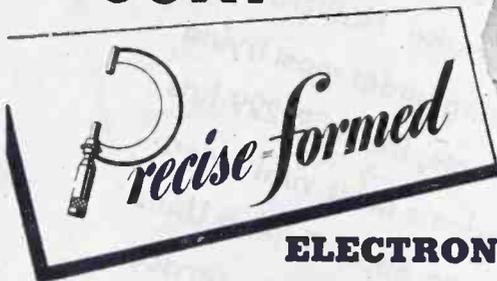
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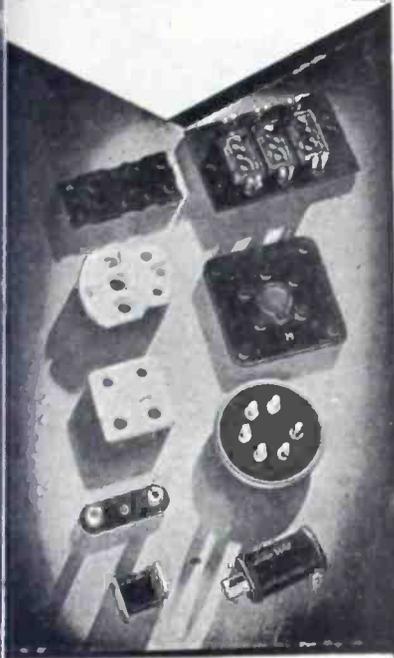
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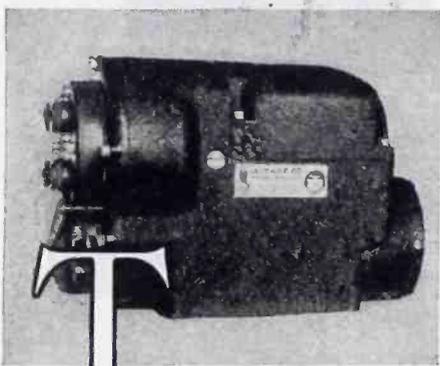
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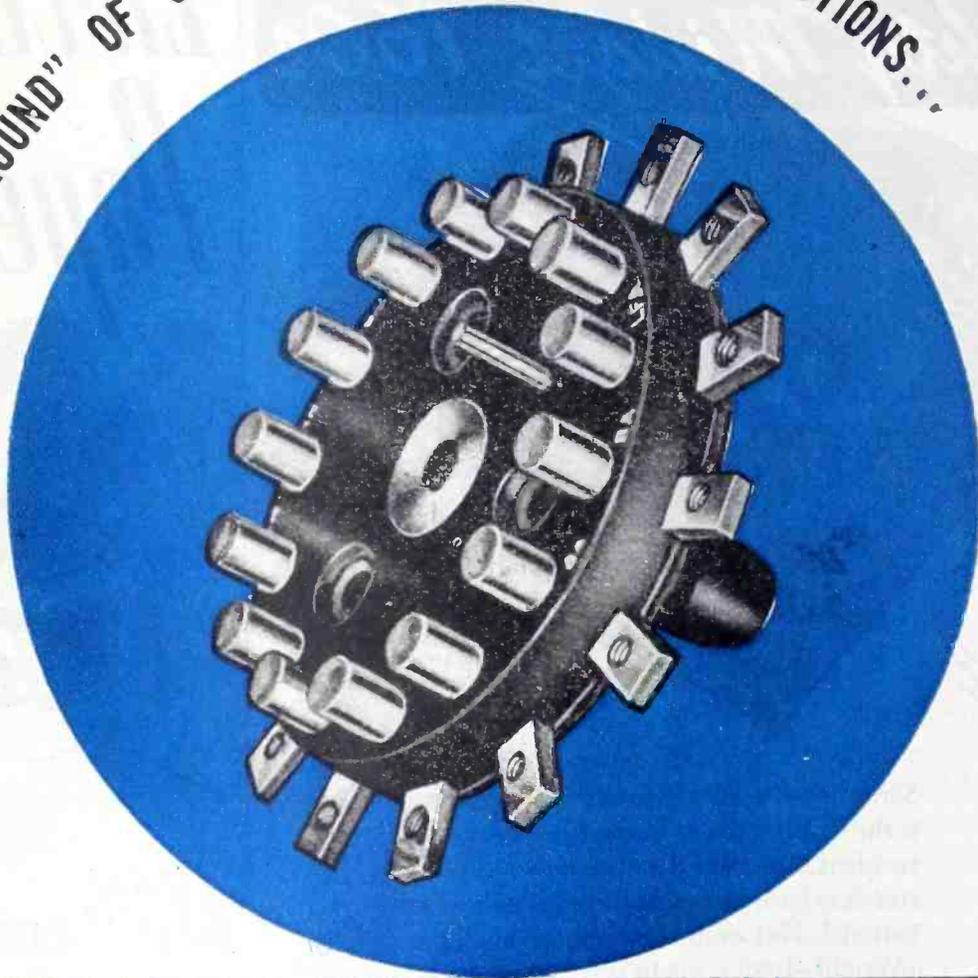
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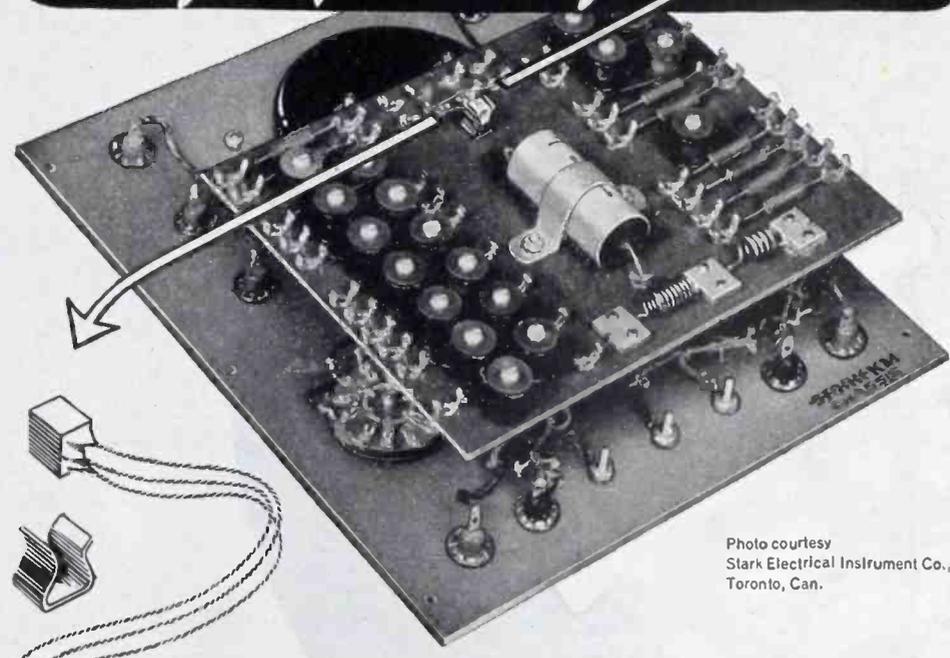


Photo courtesy
Stark Electrical Instrument Co.,
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ELECTRICAL LABORATORIES

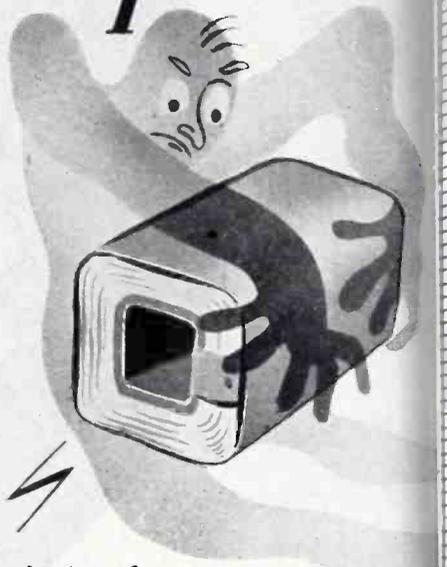
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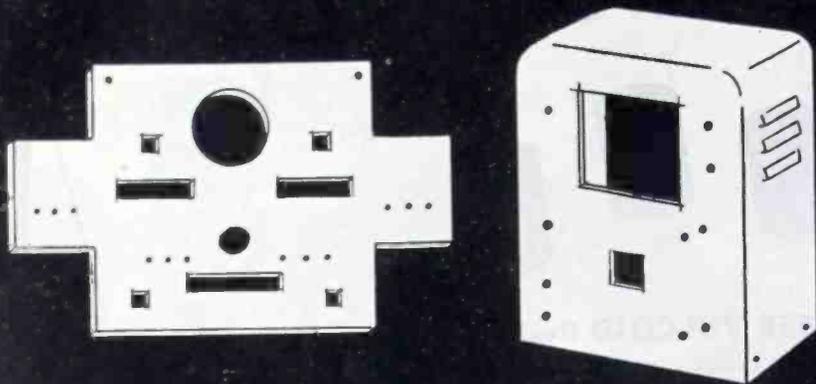
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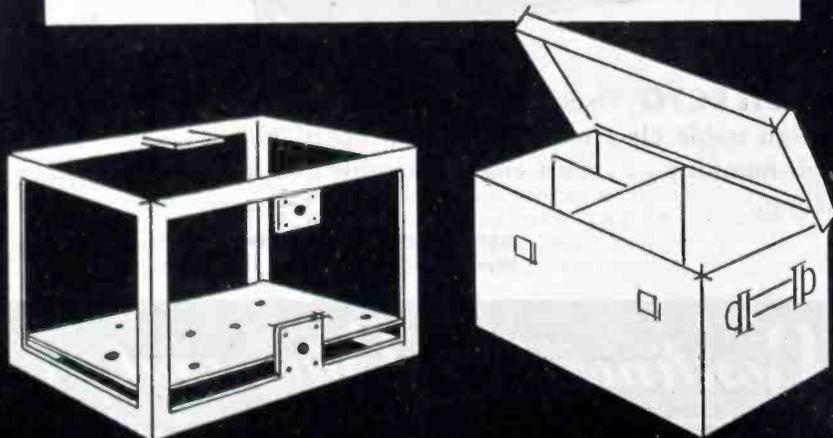
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If the answer to any of the above questions is YES, write us for further information or consultation on specific jobs.

PORTER

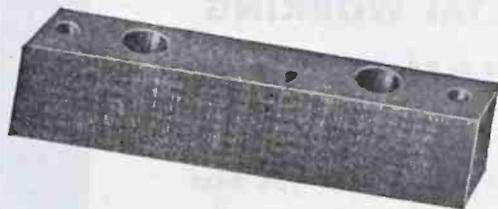
METAL PRODUCTS COMPANY
490 JOHNSON AVE. • BROOKLYN, N. Y.



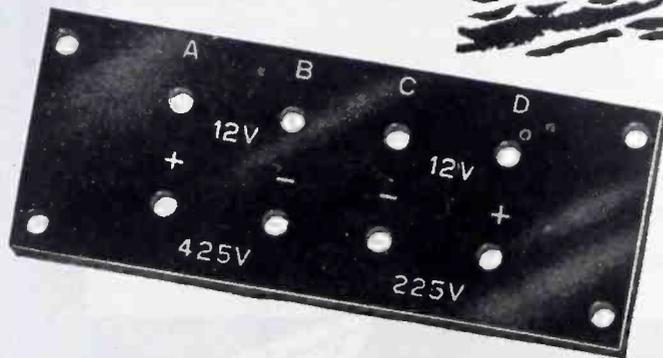
VITAL UNITS ARE C-D INSULATED



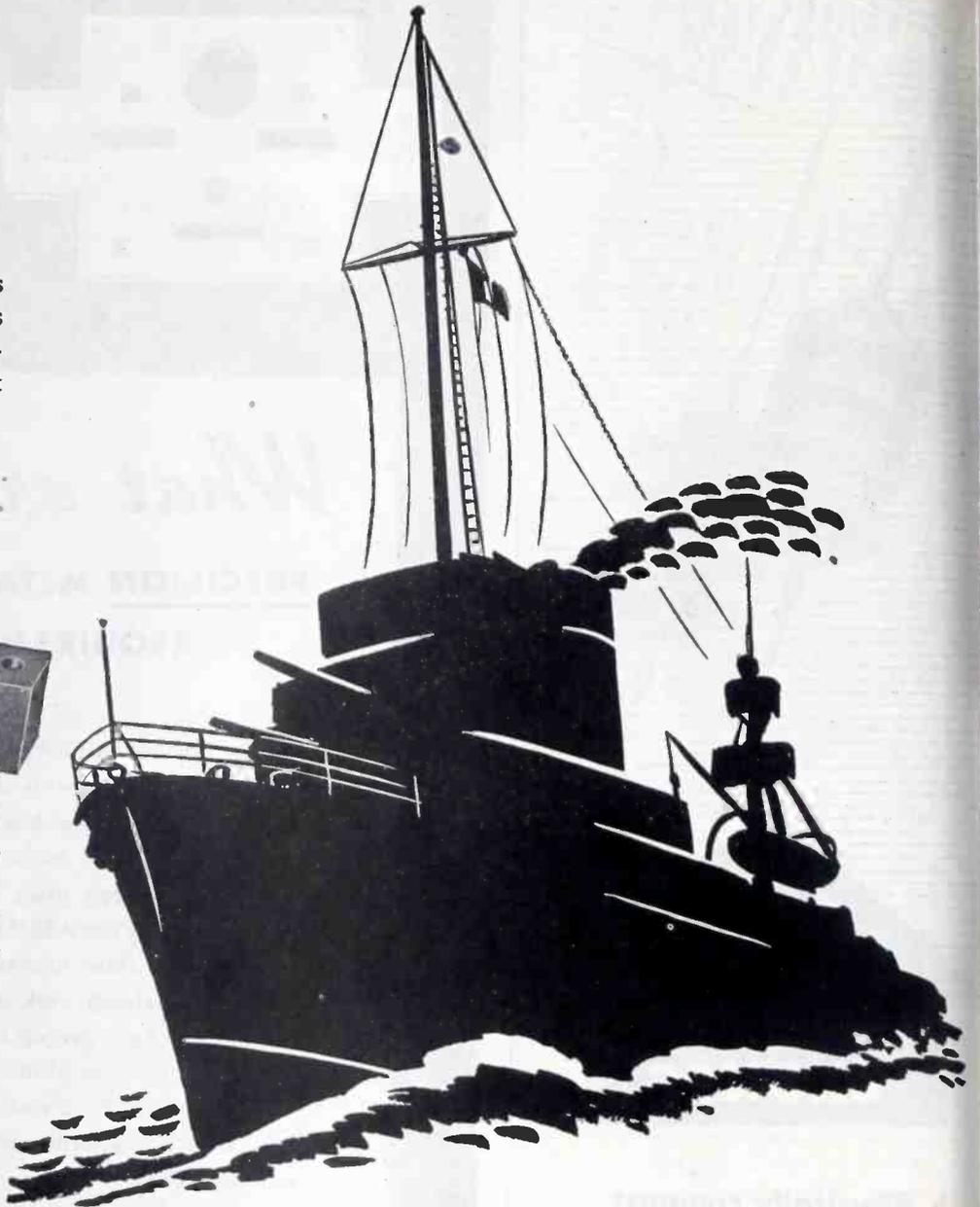
THESE VULCOID Bushings used as generator Lead Bushings . . . must be strong . . . good electrical insulators . . . and resist carbon deposit from arcs.



THIS DIAMOND FIBRE part is a switch gear baffle plate support. It must be a good insulator . . . must be mechanically strong and must be readily fabricated.



THIS DILECTO Dynometer Terminal Board must have high stable electrical insulating properties even in high humidity . . . must engrave readily and must be strong.



Many hundreds of C-D insulating parts are used in our Naval Equipment. C-D insulating materials are engineered to meet specific electrical, mechanical and thermal problems . . . Booklet GF gives technical data on all C-D materials. . . Send for your copy today!



DISTRICT OFFICES: New York - Cleveland - Chicago - Spartanburg, S. C.
West Coast Rep., Marwood, Ltd., San Francisco - Sales Offices in principal cities

CP-44

Continental - Diamond FIBRE COMPANY

Established 1895. . . Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE

HOW DO YOU KNOW THEY WON'T "FORGET" THE LOCK WASHER?



THEY CAN'T "FORGET" WITH *SEMS* FASTENER UNITS!

● The Sems Fastener Unit is a combination of a pre-assembled Shakeproof Lock Washer and Screw . . . a lock washer is on *every* screw, and it can't drop off!

Using Sems Units makes the entire assembly operation faster and more efficient with the assurance of locked-tight parts. Sems Units help solve many other assembly line problems especially by eliminating unnecessary, time-wasting operations. Shakeproof Engineers can prove these advantages and show you the most practical way of using this fastening on your products. Write today . . . a field engineer will consult with you immediately!



***SEMS* FASTENER UNITS**

Reg. U. S. Pat. Off.

Pre-Assembled Shakeproof Lock Washer and Screw Worker can't "forget" the lock washer • Lock washer can't drop off • No lost or wasted lock washers • Only one unit to handle • Saves time • Speeds assembly

Write for Free Test Kit No. 23

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Fastening Headquarters

Distributor of Shakeproof Products Manufactured by ILLINOIS TOOL WORKS
2501 North Keeler Avenue, Chicago 39, Illinois

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Other Shakeproof Products Include:

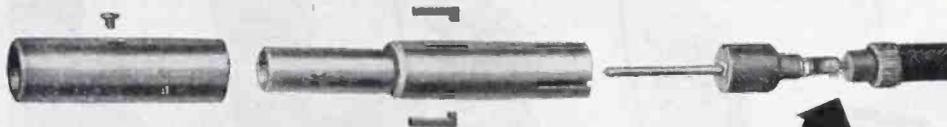
Shakeproof Lock Washers with Exclusive Tapered-Twisted Teeth

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ANDREW COAXIAL PLUGS AND JACKS



IMMEDIATE DELIVERY

in moderate quantities from stock

ANDREW coaxial plugs and jacks are used as connectors for flexible coaxial lines, and fit many of the standard Army and Navy approved cables. They are especially useful where a simple panel mounting plug-in type of connector is required.

Machined from brass bar stock, these sturdy plugs and jacks provide a positive connection between the outer conductors and between the inner conductors. Inner conductor contacts are silver plated to obtain maximum conductivity. Insulation is the best grade of Mycalex. Patch cords are made of low-loss flexible coaxial lines of 72 ohms surge impedance. Patch panels consist of 24 jacks mounted on a 19" relay rack panel.

WRITE FOR BULLETIN
NO. 31

ANDREW CO.
ANDREW
363 East 75th Street
Chicago 19, Illinois

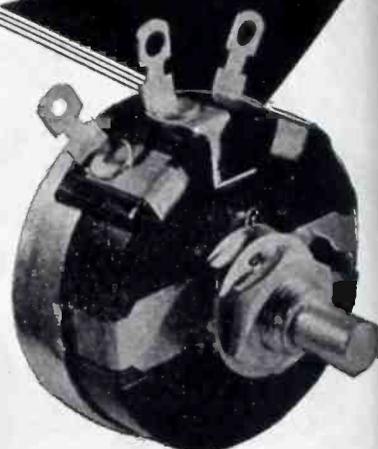


Illustration shows panel with patch cord in place.

ONLY ANDREW
offers this easy
accessibility for
soldering.

You don't have to solder through a window to install an ANDREW plug or jack. Just remove one screw, slide the sections apart with your fingers and solder. This is a new improvement invented and used exclusively by ANDREW.

A decade and
a half of
refinement...



CLAROSTAT WIRE-WOUND *Controls*

★ This latest Clarostat Type 58 wire-wound rheostat or potentiometer is a still tougher control. And provably so. It copes with extreme vibration and mechanical abuse, fully matching its electrical ruggedness. Note these refinements:

Metal locating pin. Will not break or tear off.

Metal strap grounds metal cover. Keyed cover will not loosen or turn. Fully dust-proof.

Bushing keyed into bakelite casing. Cannot slip or turn when

locking nut is tightly drawn up.

Center rail and terminal in one piece. Direct connection between winding and "L" and "R" terminals.

1500 v. breakdown insulation between winding and shaft.

★ Write for
Literature



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TOMORROW'S "five-foot shelf of books" may well hold thousands of volumes of this sort—books on micro-film, projection on screen, wall or bedroom ceiling. Educators especially can use them to make study books more enjoyable. The equipment to make and project such books will call for infinite precision... available on a mass-production, low-cost basis.

That has been our preoccupation for the last thirty years and war has only intensified the lessons we've learned

about mass production of close tolerance on an efficient basis.

Like many producers for the war effort, we have completed the initial phase of our war program. Adjustments now make it possible to a limited extent to invite inquiries for production of precision parts for future delivery.

(Below) A few of the many thousands of our precision parts that help "Keep 'em flying and fighting."



Let's all back the attack — Buy EXTRA War Bonds



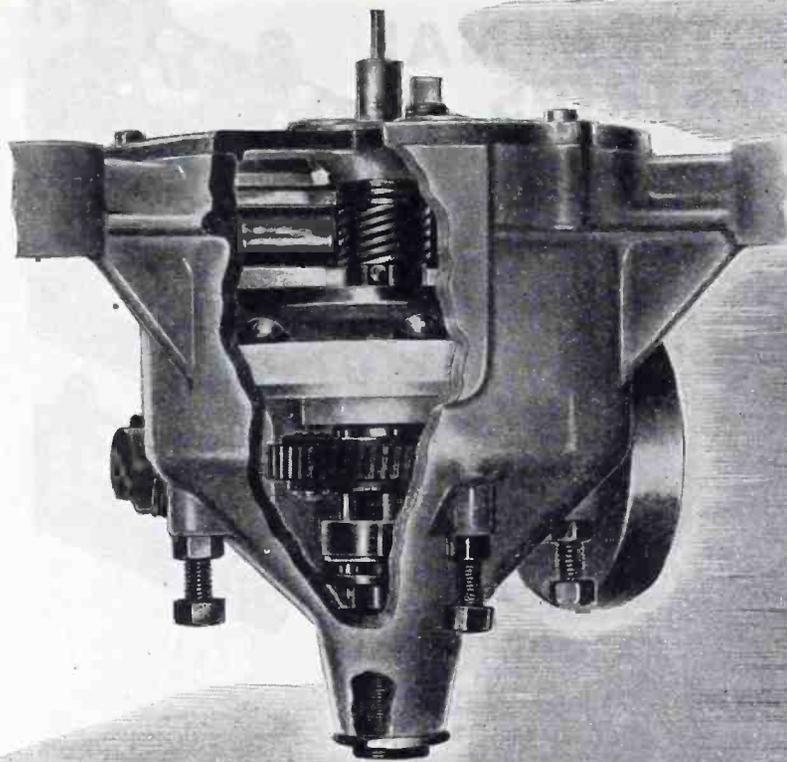
ERICSSON

SCREW MACHINE PRODUCTS CO., INC.

25 LAFAYETTE STREET, BROOKLYN 1, N. Y.



'WOW'
FREE



Fairchild No. 539
Portable Recorder

at the critical 33.3 rpm speed

'WOW' is the direct result of variation in turntable speed. Its positive elimination — particularly at the critical 33.3 rpm speed — calls for the positive Fairchild drive.

The Fairchild turntable is driven direct from the center. The 33.3 rpm speed is obtained by a 54 to 1 gear-and-worm reduction of the 1800 rpm synchronous motor speed. The evenness of the speed is obtained by a carefully calculated loading of the drive mechanism to keep the motor pulling constantly; by careful precision control of all drive alignments that might cause intermittent grab and release; by carefully maintained .0002" tolerances in all moving parts.

The 33.3 rpm speed is translated into 78 rpm by a precision

friction-bail-race stepup.

The Fairchild No. 539 Portable Recorder is equipped with the positive Fairchild drive. It was developed to meet the exacting needs of radio and communications for studio-quality recording in the field. And it is built with mechanical skill — skill long practiced in .0002" tolerance production of aerial cameras, aircraft sextants and aircraft computing gun sights.

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Fairchild CAMERA
AND INSTRUMENT CORPORATION

SOUND
EQUIPMENT



MOLDED TERMINAL STRIPS



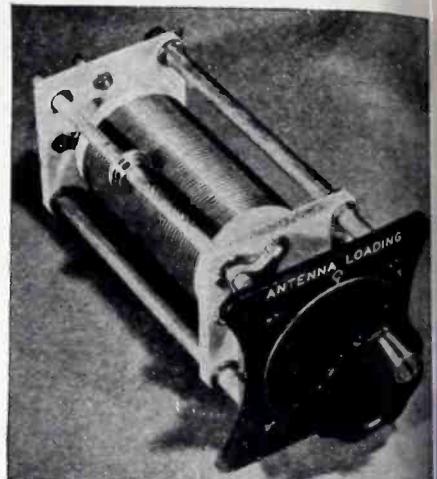
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WITH HARDWARE

Available in lengths from 1 to 20 terminals.
2 Types: NAS 17 and NAS 18. Prompt deliveries.

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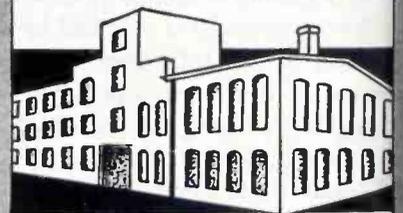
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We concentrate all our research, engineering and production skill on meeting your most difficult coil requirements. In our wide experience we have met and solved problems as complex as any now confronting you. Our engineering staff is available for consultation without obligation.

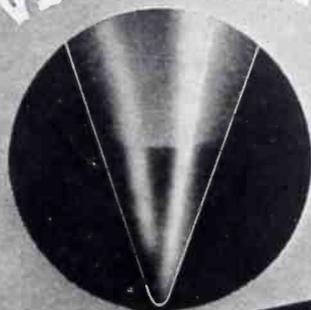


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WINDING CO.**

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**EVEN UNDER SEVERE
VIBRATION**



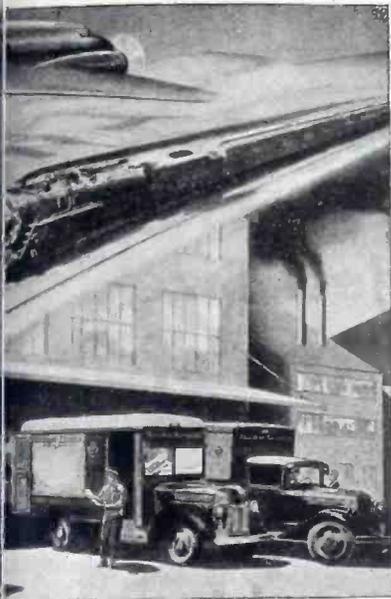
PERMOPIVOTS
GIVE PRECISION INSTRUMENTS
GREATER ACCURACY LONGER

Permometal*, the osmium alloy tip on Permo pivots,* gives them an endurance far in excess of ordinary pivots. The greater resistance to wear found in Permo pivots *even under severe vibration* is due to the alloy's extremely low co-efficient of friction and its complete freedom from abrasive material. Permo pivots are also non-corrosive and non-magnetic. Write for complete information.

*T. M. Reg.

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SAVING AMERICA TIME AND EFFORT

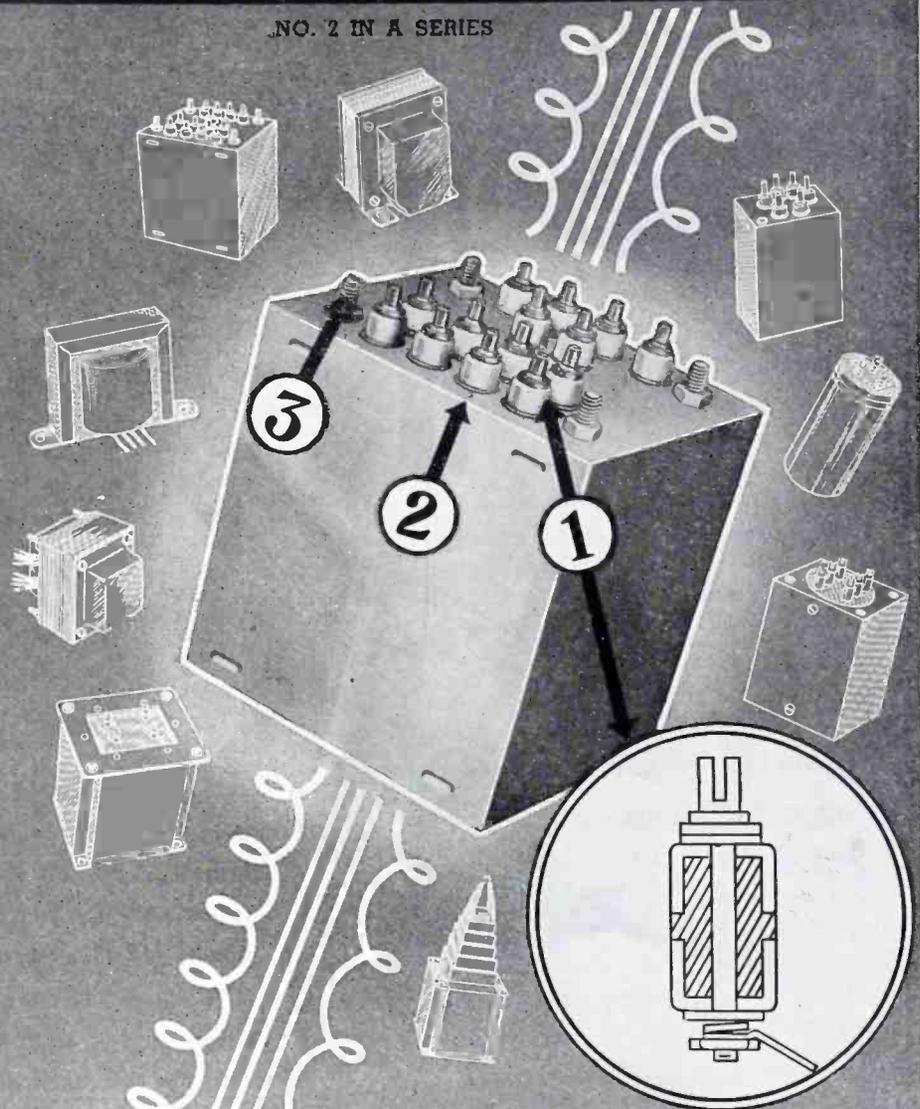
TO DEVELOP and use ways and means for saving time and effort is a typical American trait. Railway Express, with its fast trains coordinated with super-swift Air Express planes, is a time and effort-saving shipping service, unique in world transportation. These facilities, today, are being utilized to the utmost in meeting the fast transportation needs of government, industry and the public.

You can help Express continue to carry its share of today's enormous shipping load—and help yourself, too—by doing three simple things: Pack your shipments securely... address them clearly... get them off early. Out of our experience, we now "A shipment started right is half-way there."



MEET THIS MEMBER OF THE FREED TRANSFORMER FAMILY

NO. 2 IN A SERIES



*Specialized Engineering
Makes this Unit adaptable
to all Service Conditions.*

1. A cross-section of the bushing assembly, showing special neoprene gasket which insures perfect hermetic sealing and is completely fungus resistant. Sturdily constructed screw machine part set in high dielectric stealite bushing makes wiring and soldering easy.

2. Completely soldered seam assures constant, unflinching service under the most adverse climatic conditions.

3. Large size studs mount transformers to cover internally, making the complete unit absolutely shock-proof.

This transformer, built to withstand the most severe usage, incorporates many features that are a tribute to the resourcefulness and sound basic knowledge of our engineering staff. A reference to the numbered arrows indicates why Freed Transformers have been able to meet all the latest requirements of the Army and Navy... We urge any engineer struggling with an intricate problem to consult us without delay.

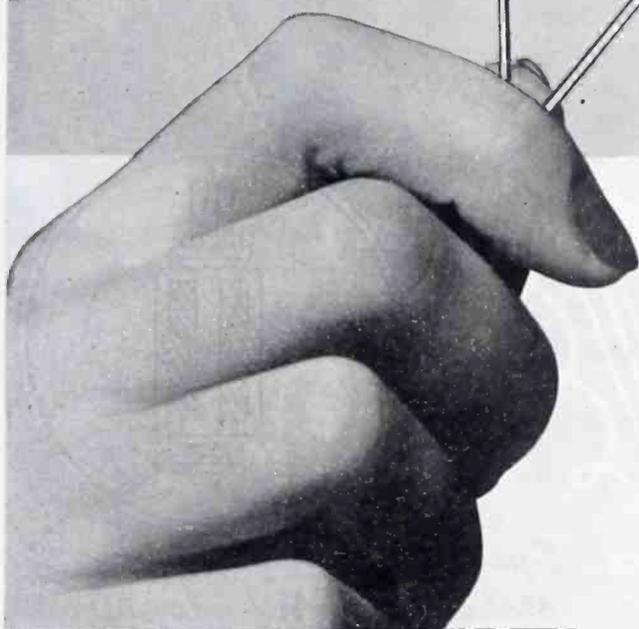
FREED TRANSFORMERS

FREED TRANSFORMER COMPANY
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Announcing
**the Highest Quality
 the Smallest Size
 2-WATT Resistor**

OLD
 Insulated Resistors
 are this large

The
NEW
 Insulated
 Type HB Bradleyunit
 Size— $1\frac{1}{16}$ " x $\frac{5}{16}$ " diam.



TYPE HB BRADLEYUNIT PASSES ALL TESTS

Will meet American War Standard tests including salt water immersion test and Army and Navy 200-hour salt spray test AN-QQ-S-91. Under Continuous Load Test of 175% load for 100 hours, or 100% load for 1000 hours, resistance change will be less than 5%.

Maximum continuous load at 40°C. ambient temperature is 2 watts. Max. continuous RMS voltage drop -1000 v. Max. momentary peak voltage drop -2000 v.

The new Type HB Insulated Bradleyunit, just put into production, matches in dependability and appearance the Allen-Bradley Type EB $\frac{1}{2}$ -watt and the Type GB 1-watt fixed resistors, which are recognized by engineers as "tops" in quality for all radio and radar applications.

The new Allen-Bradley 2-watt insulated resistor can be safely used up to its listed rating... you do not have to derate this resistor, irrespective of its application. Note the test data given below.

The Type HB Bradleyunit is available for early delivery in R. M. A. standard values from 10 ohms to 0.47 megohms, in tolerances of 5, 10, and 20 per cent.

Substitute this new 2-watt resistor in your equipment, and gain space, improve dependability, and reduce rejections.

Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis.



ALLEN-BRADLEY
FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY

Presto is taking Orders for Post-War Deliveries

NOW YOU CAN PLAN AHEAD

As a station manager, you have probably been getting reports from your engineers saying that your transcription recording and playback tables are nearing the end of their useful life.

Your car and other pre-war mechanical equipment are showing the effects of four or more years of hard, continuous service during times when replacement parts have been hard to get, some of them inferior substitute materials, and when skilled personnel has not been available for proper operation and maintenance.

YOU CAN BE AMONG THE FIRST to get your station equipment back in shape if you place your order for new turntable equipment now. Presto will assign your order a preference number based on the date and time of the postmark on your order. This number will appear on our acknowledgement.

PRIORITY NEED BE FURNISHED as no shipments will be made until the military demand for equipment is completely satisfied and priority restrictions are removed. When that time comes, your Presto preference number will take the place of a government priority in determining the delivery of Presto equipment.

NO DEPOSIT IS REQUIRED. Simply fill out the Presto post-war order form. If you need more information, send for our complete Presto catalog. Be assured that any improvements that may be added in our post-war products will be included in the equipment you receive. There will be no major changes in Presto equipment during the first year or two after the war because until that time our engineering department will be devoted entirely to war work. The fully developed equipment designs that gave you service during the long war period should, we believe, be adequate for the time immediately after the war. You will, however, receive the benefit of our experience in manufacturing recording and reproducing equipment for military service which we have gained during wartime.

WHY ARE WE TALKING ABOUT "POST-WAR" NOW?

It may seem premature until you know these facts:

1 Since early in 1942, Presto, like all other electronic equipment manufacturers, has been 100% in war work. This has meant manufacturing a variety of equipment needed more critically than recording equipment.

2 At the same time, the military demand for sound recording and reproducing equipment has been far beyond any prudent estimate we could have made.

3 Shortages have occurred continually in parts, principally motors, rubber parts and aluminum castings, as well as in labor, which have further impaired our efforts to keep shipments of our standard recording equipment up to date.

4 As a result, our backlog of orders is such that many orders received now, even those bearing AA-1 priorities, may not be shipped for eight to twelve months. By that time, government priorities may not be necessary.

Your order now will help us to plan our production schedule in advance for various types of equipment, resulting in speedier deliveries for you.

Your order, placed today, will not become binding on either of us until we give you firm price and delivery quotations based on post-war material costs and labor conditions. If your plans should change after you have placed your order, simply cancel the order and release your preference number to the next in line. That's all there is to it.

WHEN YOU ORDER BROADCASTING EQUIPMENT FOR NEW STATIONS, AM, FM OR TELEVISION, specify Presto transcription recording and playback tables. Many manufacturers of high grade radio transmitters and studio input equipment do not make turntable equipment. Therefore, ask the transmitter manufacturer to include Presto tables. They will pass your requirements on to us. We will deliver when they do.

WRITE TODAY FOR THE PRESTO POST-WAR ORDER FORM

Complete catalog sent on request



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Walter P. Downs Ltd., in Canada

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Plastics
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FOR *Victory!*

Ours is the plant behind many plants . . . molding plastic parts for numerous contractors who are supplying the Navy, the Army Air Forces, and the Signal Corps.

Molding millions of precision plastic parts for the Armed Forces is still our big job, but we have the time, the equipment and a highly skilled staff to handle a limited number of new contracts—and do a better molding job, *on time.*

Whether for production now, or after the War, our engineers are ready to work with you immediately. Write us today and let us know your molding problems.

Member: Society of the Plastics Industry

Automatic
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Small and large parts
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Crystallite, Lucite,
Ethyl Cellulose,
Polystyrene, Lustron,
Styran, Vinylite, Loalite,
Cellulose Acetate and
others . . . all molded to
your exacting
specifications.

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ELECTRO-PNEUMATIC RELAY

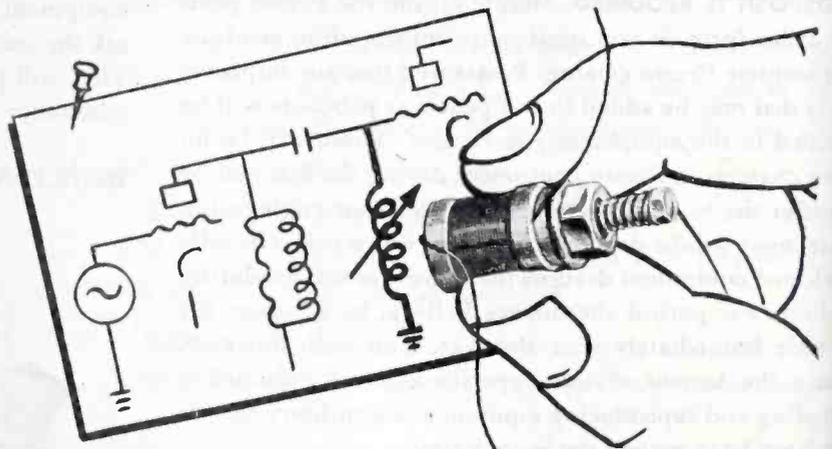


COMPACT:
4 IN HIGH
2½ IN DEEP
2½ IN WIDE

WEIGHT:
1½ POUNDS

ELIZABETH A'G'A NEW JERSEY
AMERICAN GAS ACCUMULATOR COMPANY

If this tiny **ULTRA-HIGH FREQUENCY I-F TRANSFORMER** fits into your plans...

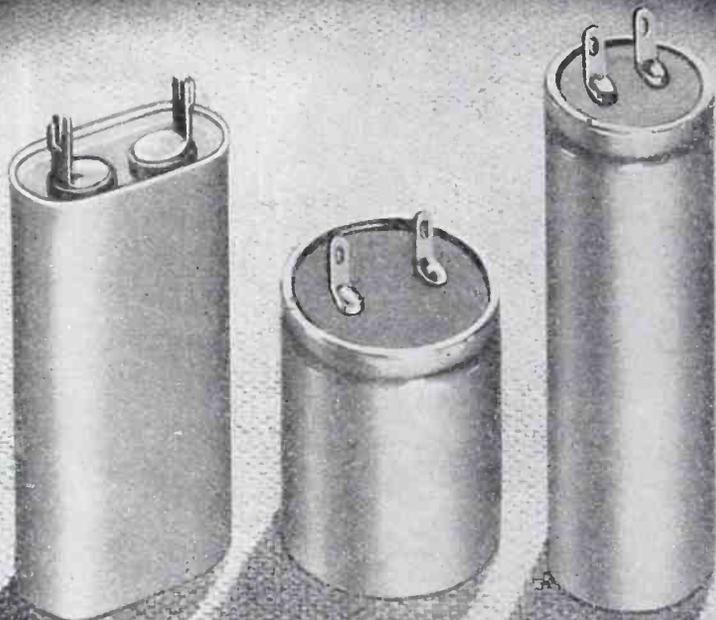


your transformer worries are over. It's the LS-1 Transformer, developed by C. T. C. for some high priority radio and electronic equipment and only recently released for more general applications. Tested and proved, this precision built, slug tuned transformer will meet your highest standards of quality and performance. And C. T. C. will do everything possible to meet your delivery requirements.

For complete information on the LS-1, write, phone or wire

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CAPACITRON *Quality* Enters the **FLUORESCENT** Field!



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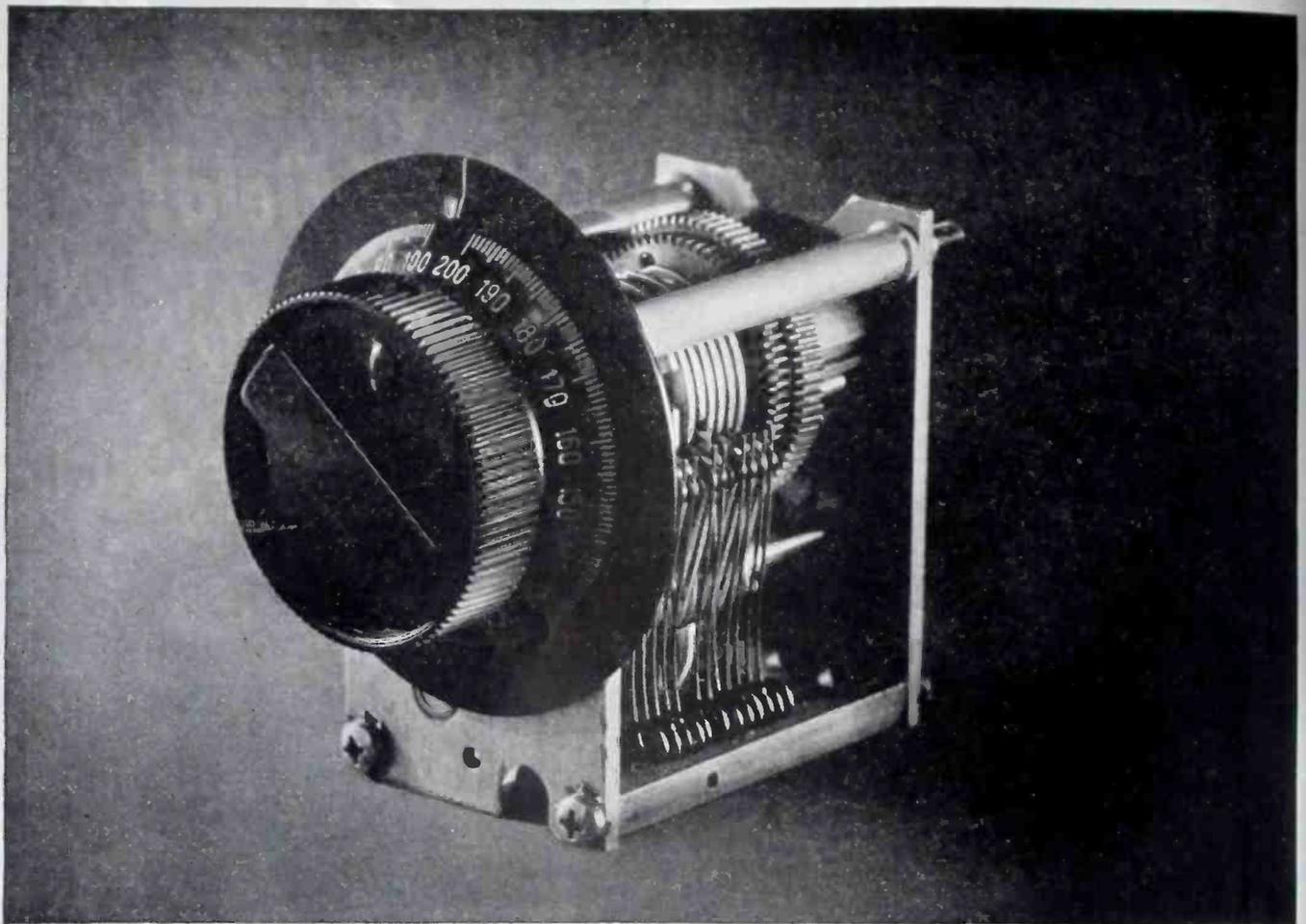
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All fluorescent type Capacitrons are designed, tested and production supervised by a specialized division of our General Engineering Department.

This group of fluorescent lighting men can supply you with economical standard and special capacitor designs for long life based on years of actual field experience. They will gladly assist ballast manufacturers with practical design suggestions and life tests on complete ballasts. Why not consult with them now!

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318 West Schiller St. Chicago 10, Illinois



COLLINS AUTOTUNE*

The Key to Precision Control

THE Autotune was conceived and engineered by Collins many years ago. It was the result of a growing dissatisfaction with slow, haphazard methods of tuning radio equipment and a persistent effort to improve them.

What is it? How does it work?

The Collins Autotune head shown above is a mechanical device for turning a control shaft and stopping it precisely at any one of several pre-determined positions.

The Collins Autotune system consists of a number of Autotune heads, all driven by a single electric motor, each quickly and simultaneously repositioning a separate and non-interrelated tuning shaft to new settings chosen in

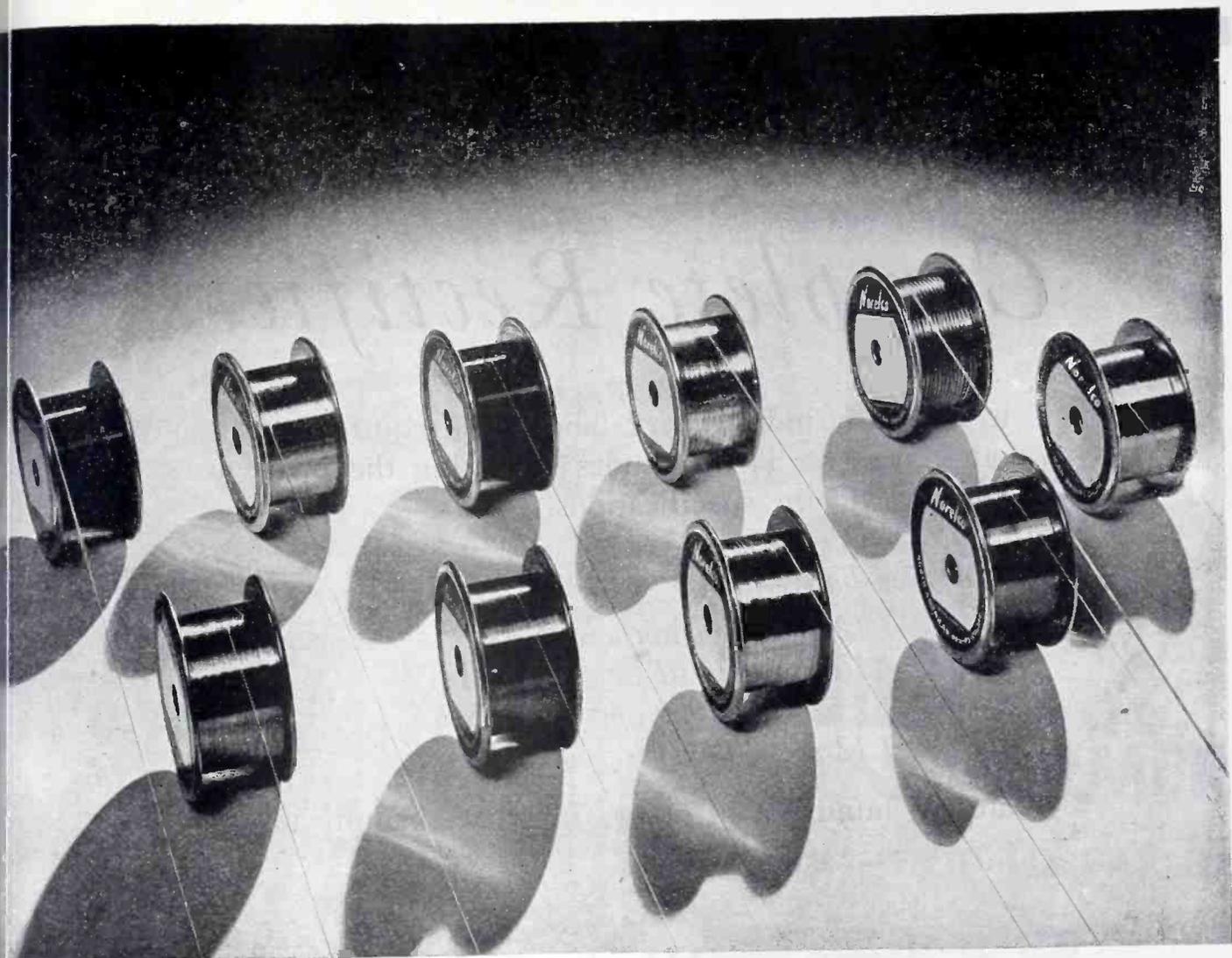
advance by the operator. At the touch of a button or flip of a dial, the Collins transmitter or receiver is thus completely and exactly tuned to the wanted channel in a matter of seconds.

Collins communications equipment, Autotune controlled, was adopted by American Airlines, Braniff Airways, Tropical Radio Telegraph Co. and others long before the war. Reliability has been demonstrated through the years under all service conditions.

The Collins transmitter design and the Autotune have proved so advantageous to the Armed Services that military authorities have requested other large companies, in addition to Collins, to build them. The Collins Radio Company, Cedar Rapids, Iowa.



*U. S. Patents issued and pending.



Why we are known as FINE WIRE SPECIALISTS

Drawing fine wire with rigid requirements of close tolerance, perfect roundness and faultless surface condition is an every day production accomplishment at North American Philips.

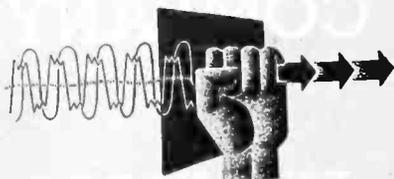
If your specifications call for fine wire below .003 diameter in silver, nickel, copper, aluminum alloy, resistance wire, or plated wires up to .010 such as gold, copper and nickel on silver, tungsten, molybdenum, alloys, etc., we solicit your inquiry.

Manufacturers who have come to us with their problems usually remain as steady customers. They look upon North American

Philips as *fine wire specialists* because we have:

- Efficient equipment designed by us to meet our own exacting specifications.
- Superior craftsmanship.
- A specialized engineering service.
- Knowledge of processes and techniques developed by a technical organization with a background of over fifty years' experience in its fields.

An increasing number of manufacturers are finding our specialized skill of great value in helping them meet wartime production schedules with low losses. Why not bring us *your* fine wire problems?



Norelco Electronic Products by

Reg. U. S. Pat. Off.

NORELCO PRODUCTS: In addition to fine wire and diamond dies for our own drawing, we make: Tungsten and Molybdenum products; Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes; Searchray (X-ray) Equipment; X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Electronic Measuring Instruments; High Frequency Heating Equipment.

When in New York, be sure to visit our Industrial Electronics Showroom.

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to meet any industrial or laboratory requirements is our business. This includes analyzing the problem and writing the specifications.

We have built:

A 12 volt 3,000 ampere unit

A 10,000 volt .01 ampere unit

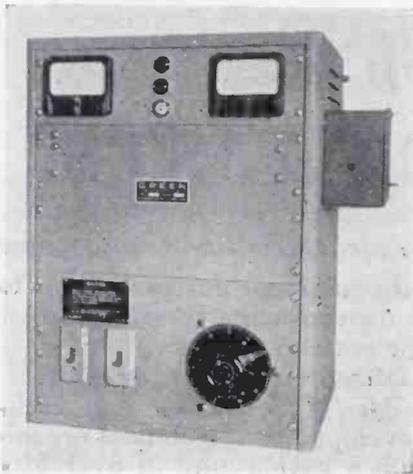
A 7.5 volt 90,000 ampere group

A 12 volt 10 ampere portable unit

among hundreds of others for special applications.



We have also built . . .
one like this



No, this is not a development model. This is exactly what the customer ordered.

"ONE 3,000 volt rectifier unit, continuously variable 0-3000 volts, capacity 500 milliamperes, filtered to below $\frac{1}{2}\%$ ripple, DC voltmeter and ammeter, input 115 volts, single phase . . . etc."



Send us your DC problem—let us submit our recommendations. Detailed description and photographs, also literature on other types—on request.

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W. GREEN ELECTRIC COMPANY, INC.

GREEN EXCHANGE BLDG., 130 CEDAR ST., NEW YORK 6, N. Y.

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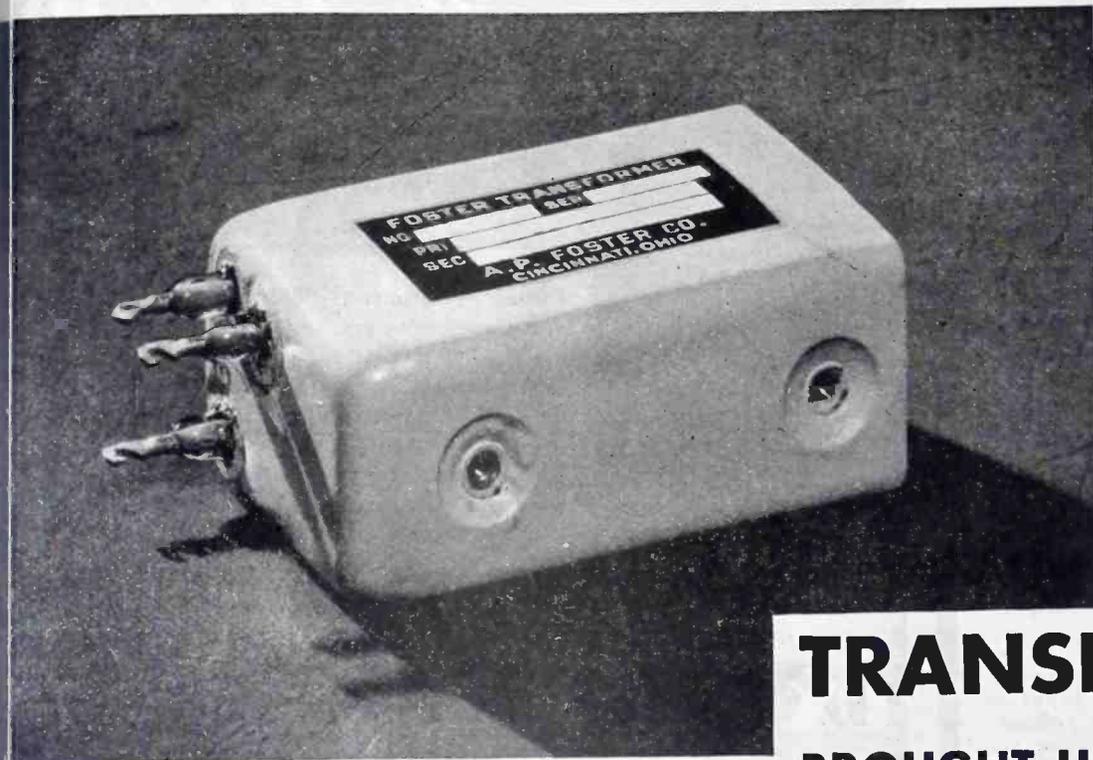
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ENGINEERS

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RE-DESIGNED "TO ORDER"



TRANSFORMER BROUGHT UP TO PAR BY **FOSTER**

Some weeks ago a manufacturer brought this unit, as then being supplied to him, to Foster Engineers for examination. Performance of the original model of this transformer had failed to meet a certain high standard of minimum inductance and maximum resistance. Foster re-designed it, met the exacting specifications, somewhat reduced its over-all dimensions, yet kept the new Foster model interchangeable with the old—no costly changes were required in the product of which this transformer is a part.

It is another example of Foster skill and experience in designing and building transformers for specific requirements that will be of great value in the post-war world of electronic equipment. Our experience covers close tolerance vibrator transformers, output transformers, microphone transformers, saturable reactors, power transformers, audio filters and reactors . . . designed and custom-built to the most exacting individual requirements.

SPECIALISTS IN BUILDING TRANSFORMERS SINCE 1938

A. P. FOSTER COMPANY

TRANSFORMER ENGINEERS & MANUFACTURERS
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AC TIMING MOTOR

Available 450 RPM (or faster) to 1 REV. per month; manufactured to your specific voltage, frequency, speed and torque requirements.



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PLAN TODAY FOR
TOMORROW**

Timing is vital today—indispensable tomorrow!

Compact, rugged and with extreme flexibility, Haydon timing motors lead the field. Manufactured to your specific voltage, frequency, speed and torque requirements, they are available with brake for instant stop—reversible, and with shift device for automatic reset.

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Reversible—compact—light in weight—7 segment commutator—low reactance rotor winding—alnico field—totally enclosed.

As makers of the most complete line of Synchronous Timing Motors, Haydon Manufacturing Company offers a complete TIMING ENGINEERING SERVICE

Haydon

MANUFACTURING COMPANY
INCORPORATED

Fosterville, Connecticut

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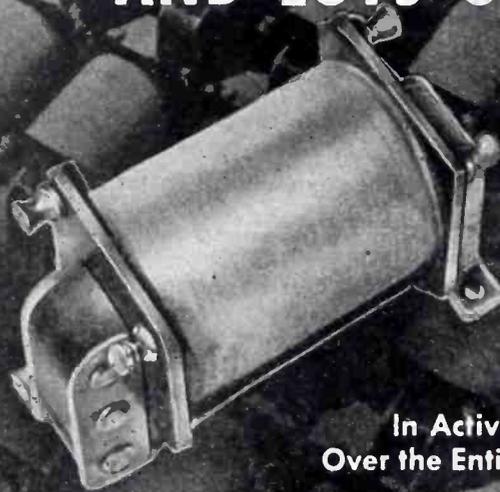
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Part I, in the October issue of "CREI NEWS," will deal with such preliminary matters as the meaning of impedance function, the classification of networks, the meaning of circuit equivalents and the requirements for two-terminal and four-terminal equivalents.

You will find this material interesting as it represents a discussion of networks from a somewhat different viewpoint from that found in the usual text books. It is not a mere recitation of certain theoretical facts, but instead, it is a demonstration of the application of such rules to practical circuit problems encountered by the radio engineer.

These articles are available free of charge. Simply write to the Institute and request the October issue of "THE CREI NEWS" containing the article on "Circuit Equivalents."

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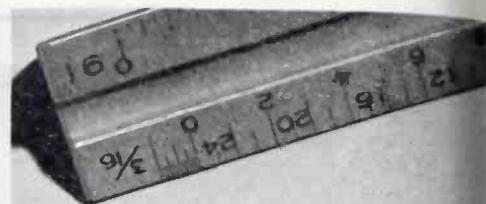
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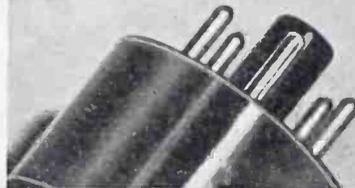
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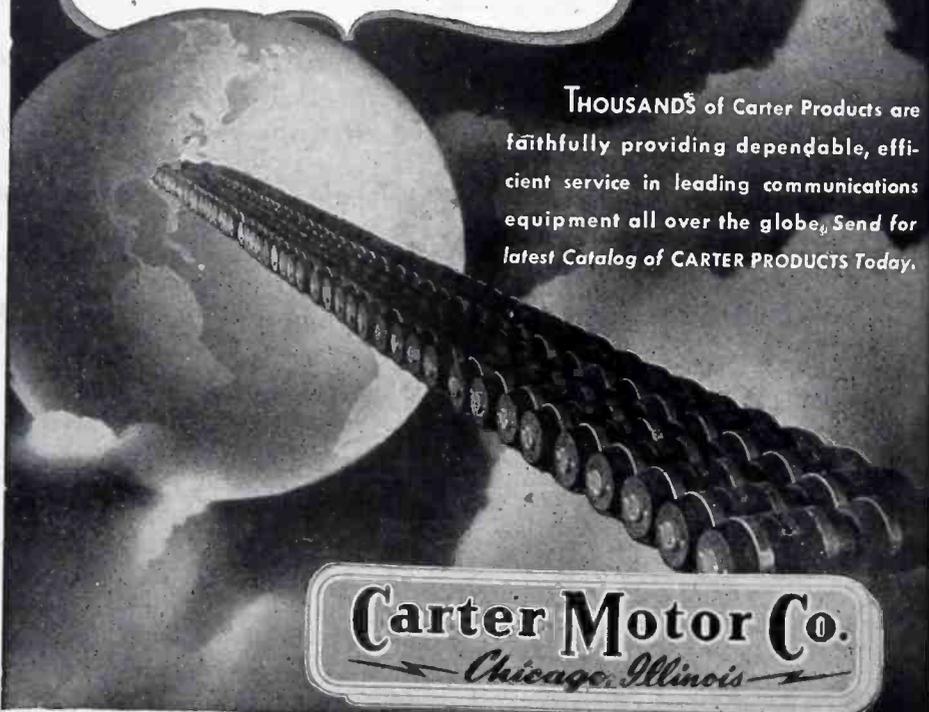


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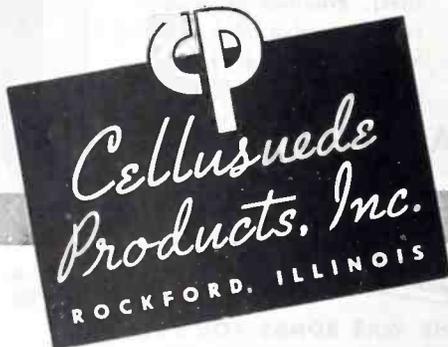
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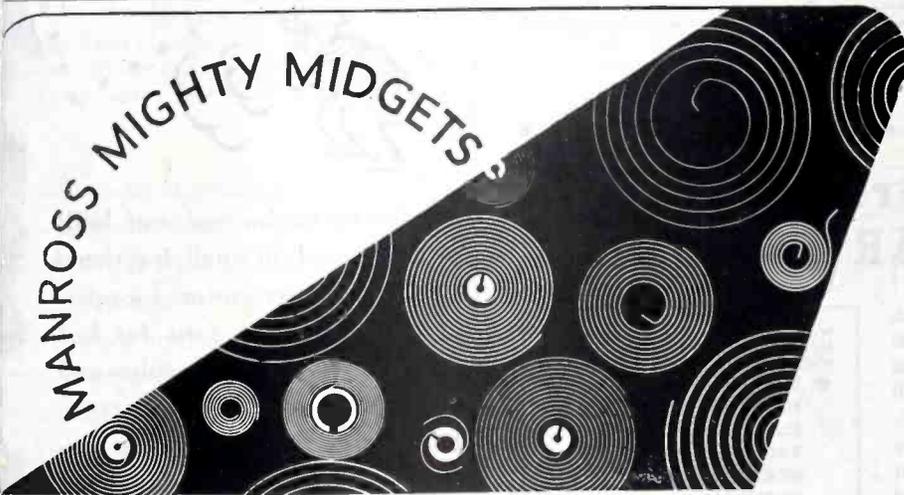
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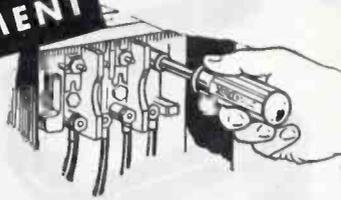
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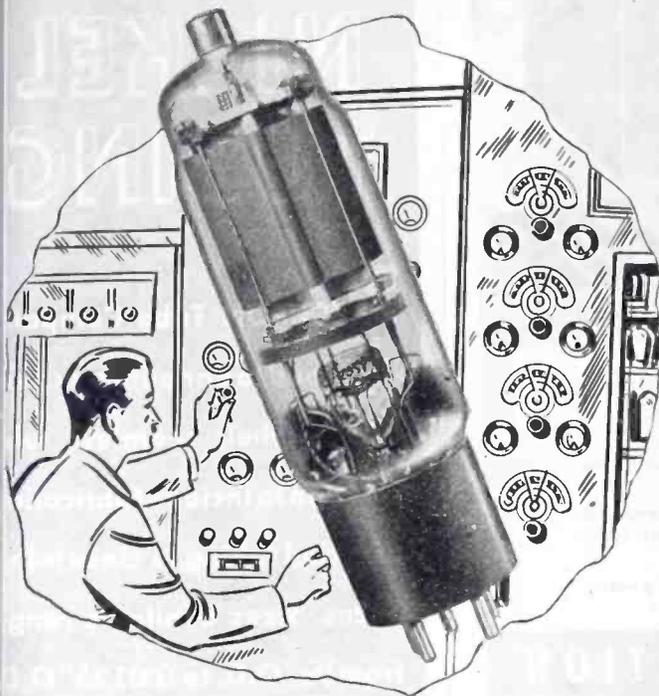
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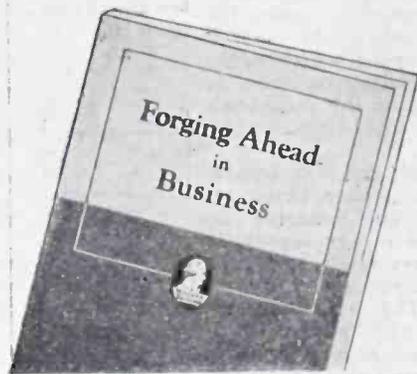
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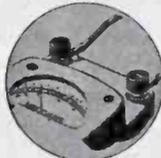


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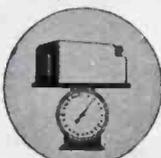
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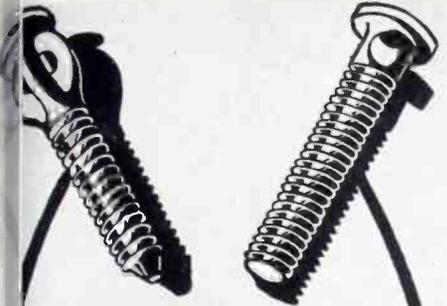
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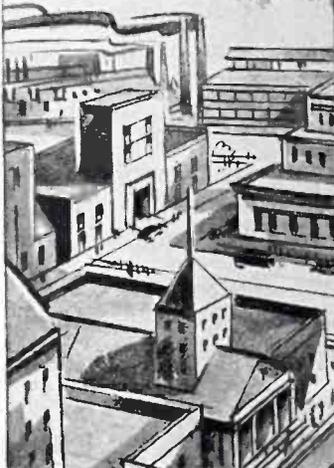
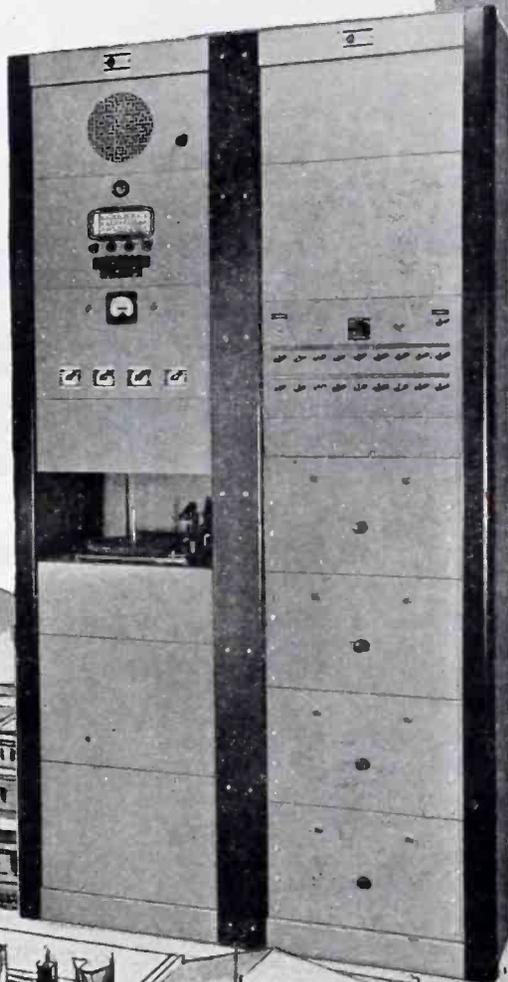
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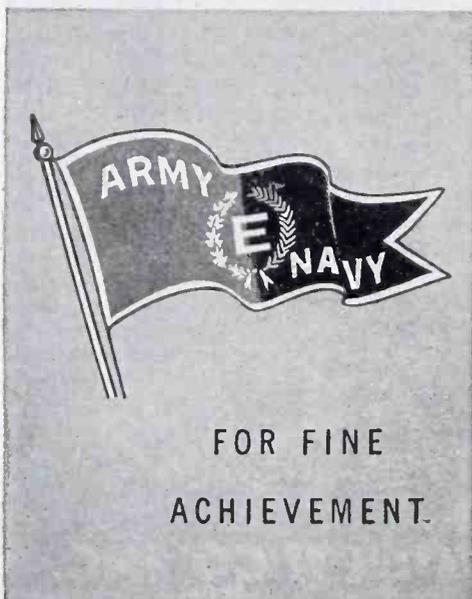
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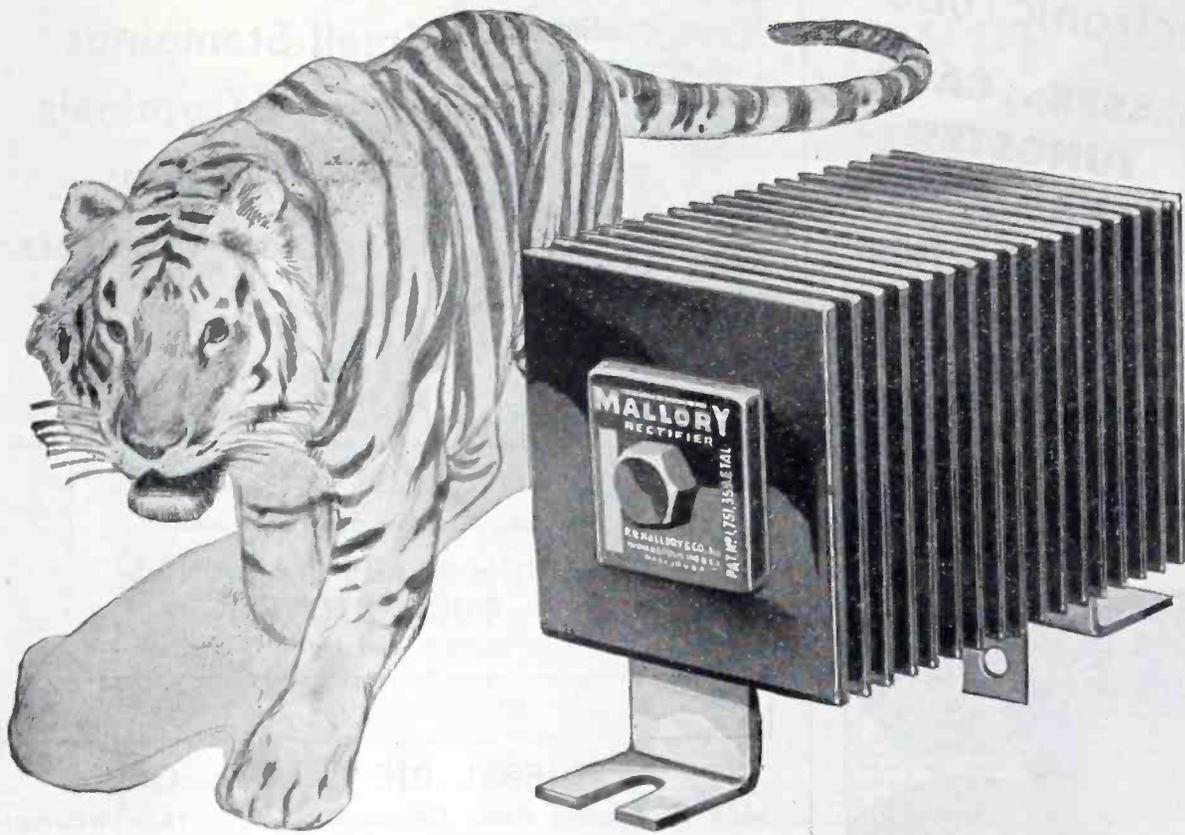
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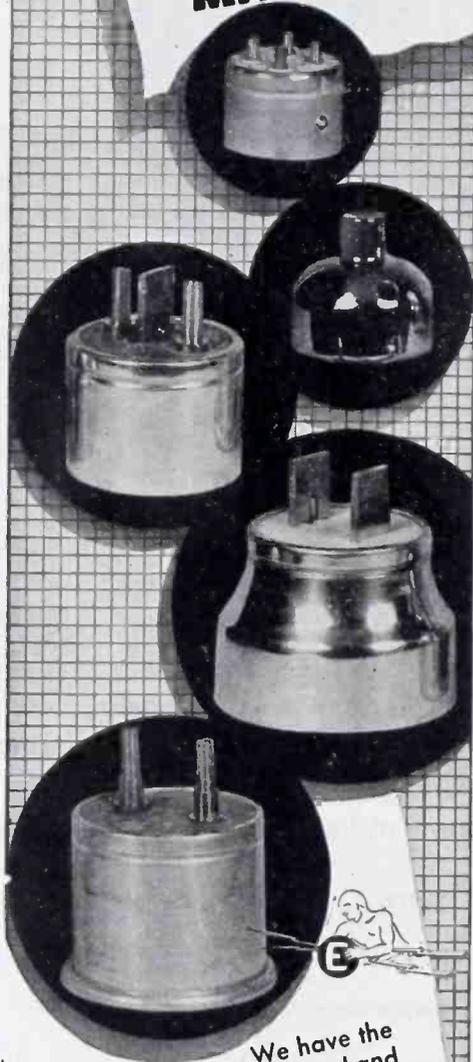
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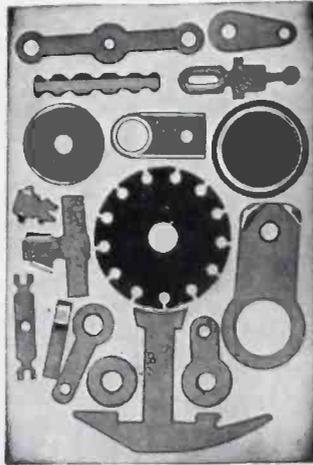
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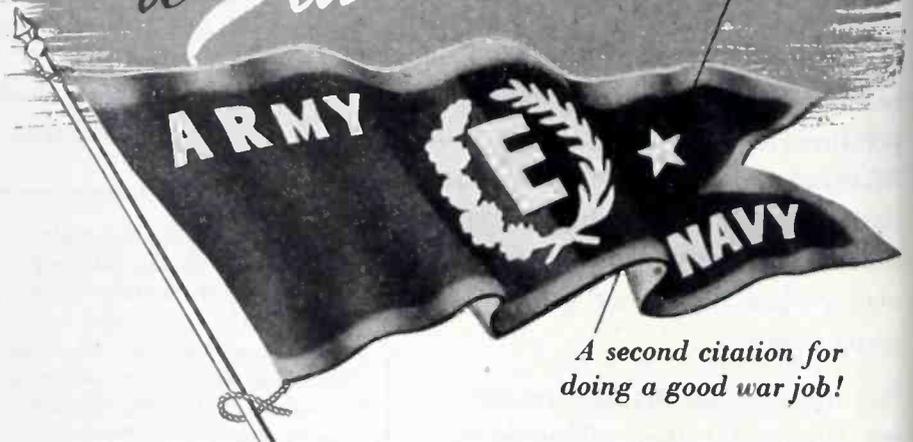
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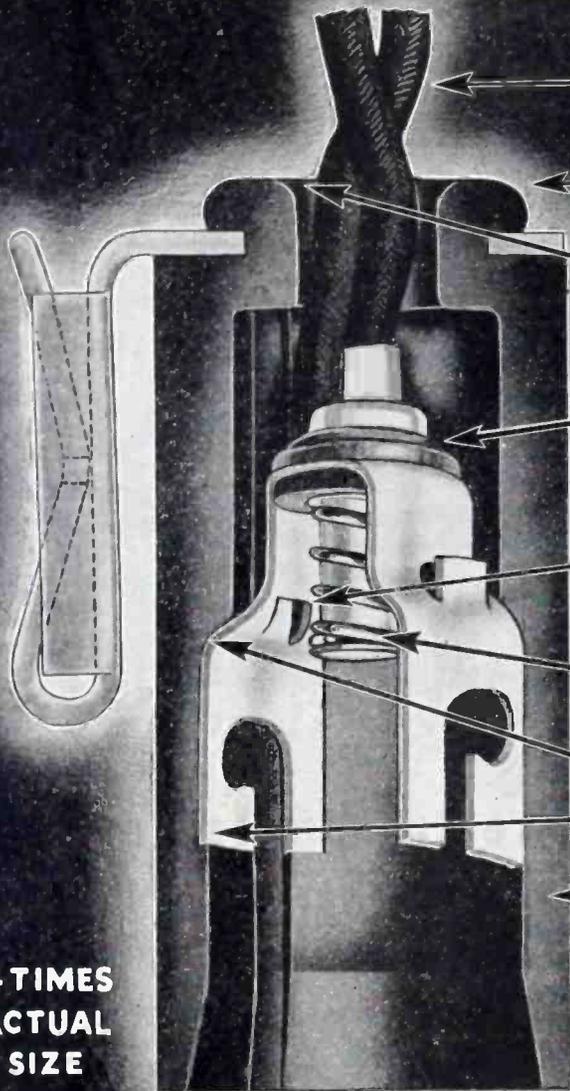
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Lug on contact fits in groove in shell so that contact cannot be turned or twisted when inserting lamp.

Center contact mounted so that it cannot protrude from shell and short on chassis when lamp is removed.

Plastic shell is recessed for contacts, which cannot be pushed or pulled out of position.

Stronger, tougher, heavy walled plastic shell.

A variety of different mounting bracket styles available, suitable for practically any mounting.

For Your Present and Post-War Production

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This year Lenz celebrates its 40th year of service to the communications industry.

Lenz Dial Light Sockets have always been known for their superior mechanical qualities and electrical characteristics.

Now these sockets are still further improved, with even greater mechanical strength. A stronger, tougher plastic shell is attached to the bracket with a new type of construction that provides a virtually unbreakable bond between shell and bracket. Its excellent electrical characteristics are maintained.

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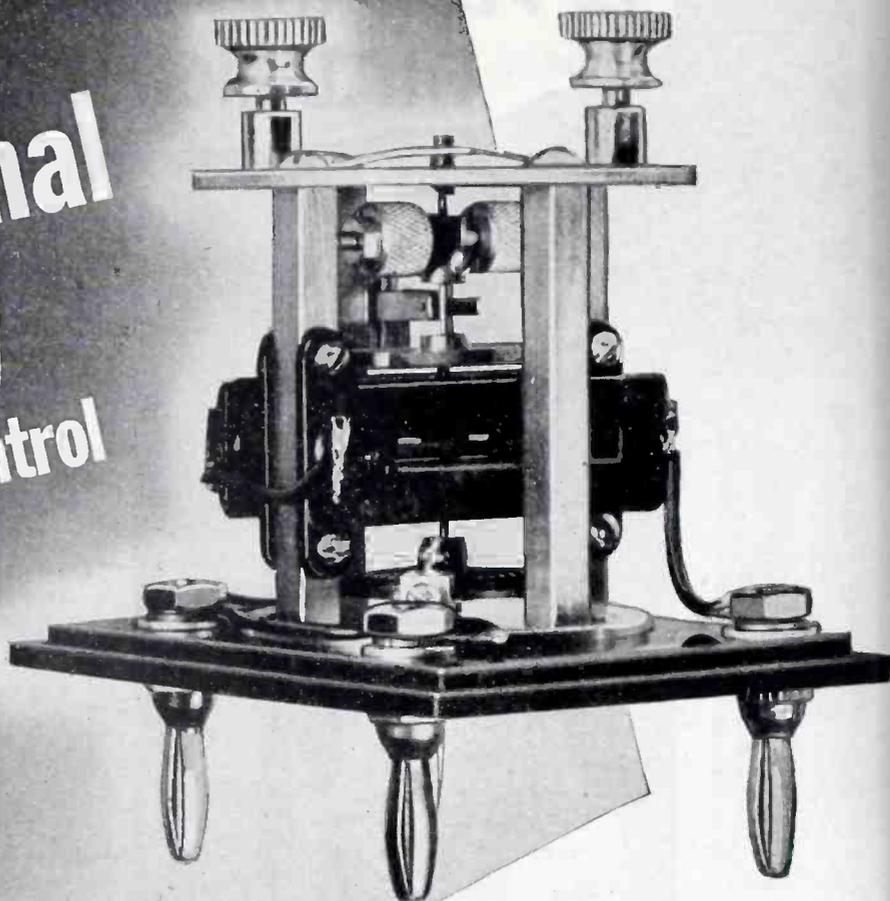
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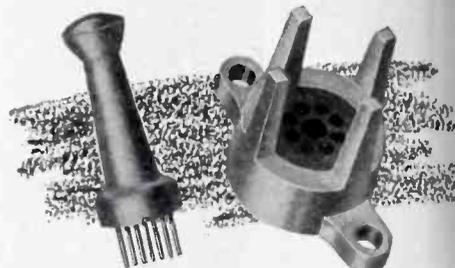
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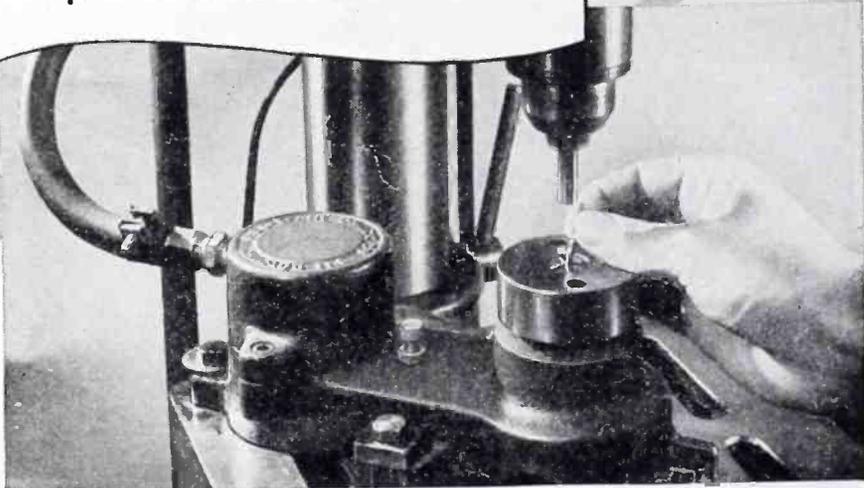
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Now—Air Operated Collet Chuck Relieves Second Operation Work on Screw Machines

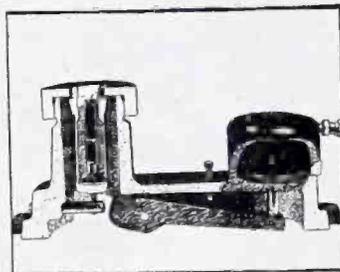
Work formerly requiring automatic or hand screw machines can now be done at much less cost through the combination of this new air chuck and any drill press. The Redmer Air Chuck is a collet air chuck using standard Brown & Sharpe type screw machine collets. The collet remains stationary, the opening and closing controlled by a sleeve action.

By using a collet as the chucking means, slight variations in the diameter of the work as frequently experienced with automatic and hand screw machine products can be permitted without sacrificing accuracy or concentricity. Thus accomplishing an important saving in time and cost.

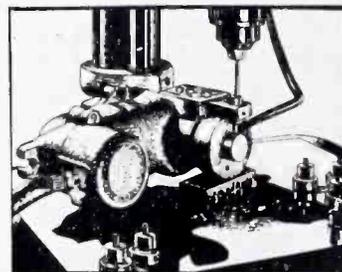
The air chuck is an ideal tool for holding parts for drilling, milling, slotting, burring, chamfering, boring, counterboring, tapping, threading, reaming and other work where the machine operation should be concentric with the chucking surface. It is adaptable to many different jobs merely by changing collet and stop. This results in saving of valuable production metals and materials. The chuck will take any type work whether round, hex, square or rectangular, and permits full efficiency of the operator, as it is operated by a foot operated valve thus leaving hands free to load and unload—reducing fatigue and cutting unproductive time to a minimum.

Wrigley's Spearmint Gum, too, is a help on the job. For chewing gum helps relieve dry throat, and helps ease fatigue brought on by the strain of work. And at the same time you are chewing and getting the benefits of swell tasting Wrigley's Spearmint, both hands are free and you need not take a "time out." The Army and Navy have recognized these benefits and are now shipping overseas only, all of the limited production of Wrigley's Spearmint. When Wrigley's Spearmint can again be produced in sufficient quantity for all, the valuable benefits of Wrigley's Spearmint Gum now being proven on the battlefield will apply to industry here at home.

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IT SIMPLIFIED A LIGHT AND POWER PROBLEM IN AIRCRAFT BUILDING

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MASS PRODUCTION of aircraft created the situation where a number of people had to work inside the cramped confines of aircraft sections . . . each person bringing in a power tool, or light, on the end of a long extension cord attached to an outside receptacle. The result frequently was an annoying confusion of wires.

At the request of one of the large aircraft companies, the Hubbell Development Laboratory designed the Four Outlet Twist-Tite Cluster Receptacle. With this device a single power line running into the airplane provided a convenient outlet for four tools. This simplified working conditions and made for more efficient production.

The understanding way in which the Hubbell Laboratory works is represented by the conveniences designed into this

product. They are described below. Similarly, every new product or improvement receives the full benefit of Hubbell's long experience in the design and manufacture of electrical connections. Most of the sockets, receptacles, connectors, plugs and switches now in common use have been Hubbell engineered, wholly, or in part.

If you require a special purpose fitting that has to do with electrical wiring, write to the Hubbell Development Laboratory. One of our technical advisers would be glad to call and discuss your requirements.

APPLICATION SUGGESTIONS WELCOMED. If you believe that the modification of any electrical outlet receptacle, switch, or connecting device will give the product broader application, send your suggestions to the Hubbell Laboratory. Also, if you have any Hubbell products, the uses of which you think are unusual, we would like to know about them. Your ideas may help others solve a problem.

THE HUBBELL TWIST-TITE CLUSTER RECEPTACLE PROVIDES . . .

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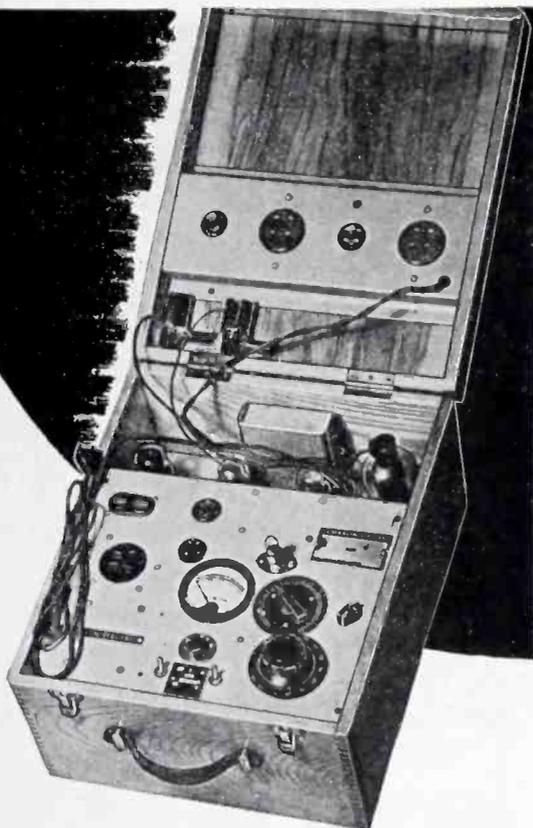


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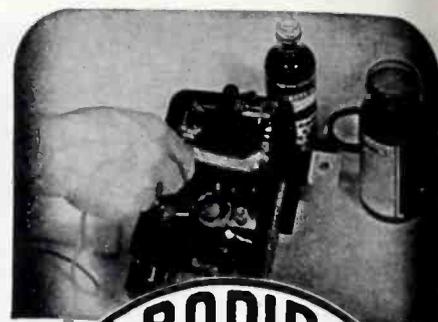
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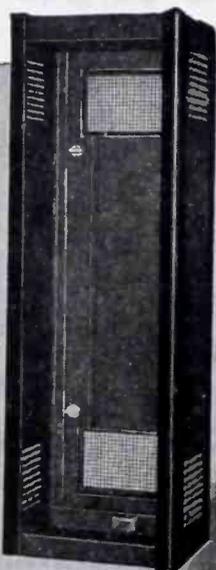
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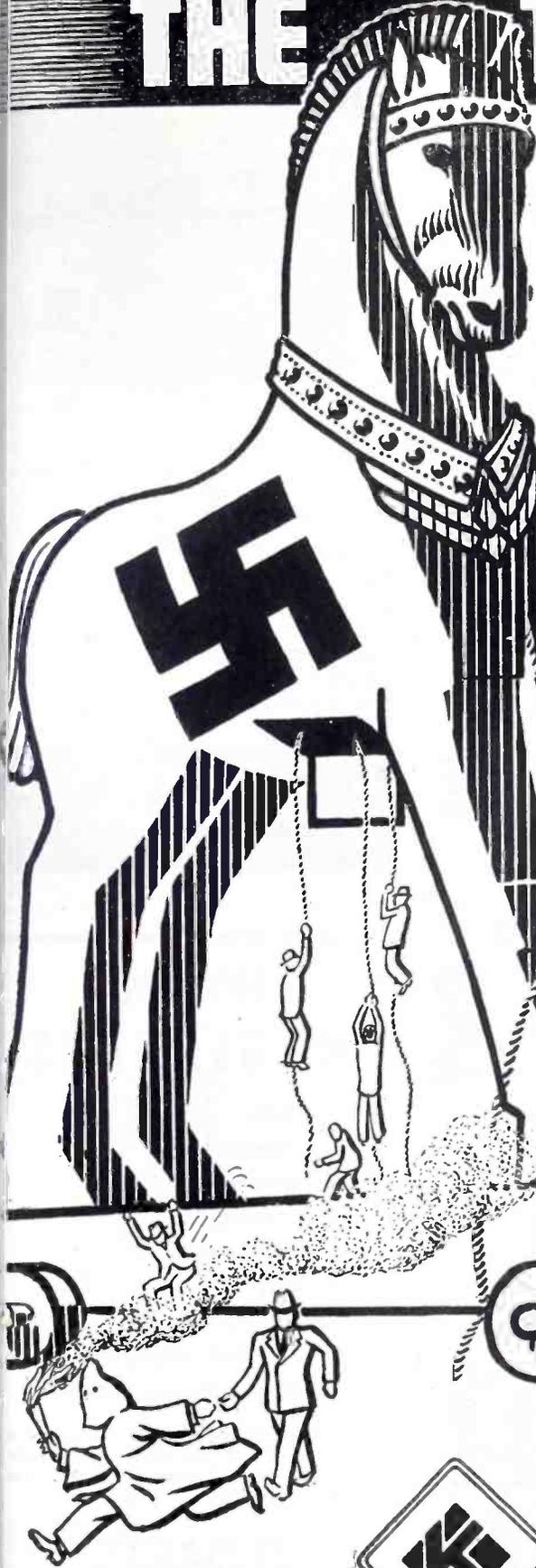
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Hitler is counting on his Trojan Horse to win Nazism's greatest victory over America, *internally*, by DIVIDING OUR NATION AGAINST ITSELF, so that IT CANNOT STAND—through deliberately creating Nazi-like racial disunion. He knows that *United We Stand, Divided We Fall*—as others before us fell! Therefore, he's working overtime to divide us. Will he succeed *here*, cancelling-out our European victories into American defeats?

It is up to YOU to defeat him decisively, every time he crawls out of the slime which is his natural habitat to rear his ugly head and spew forth his loathesome bilge.

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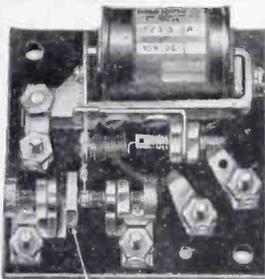
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New Feature . . . eliminates
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Oscilloscopic wave form
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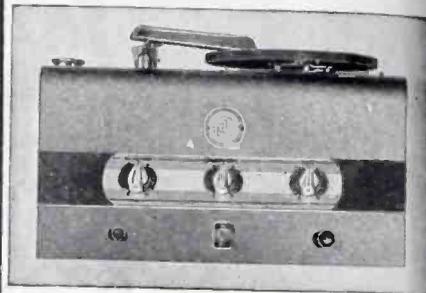
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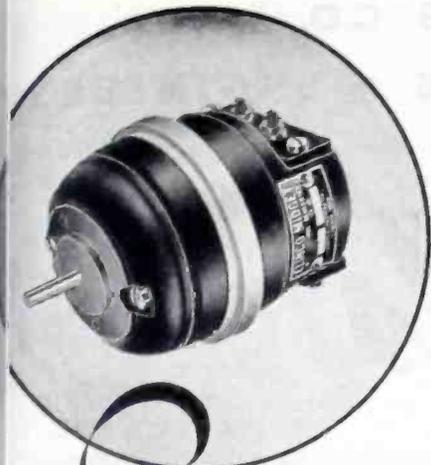
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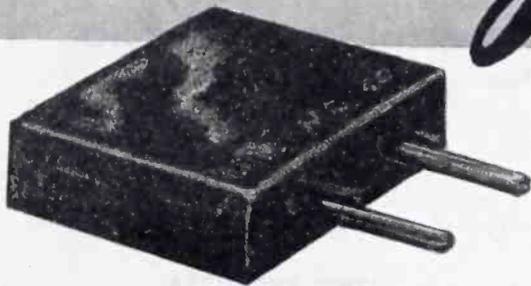
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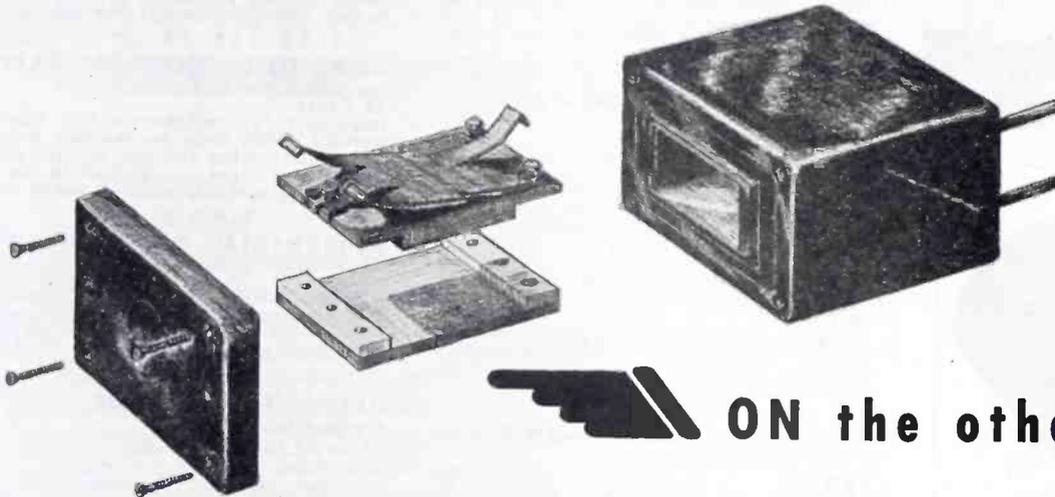
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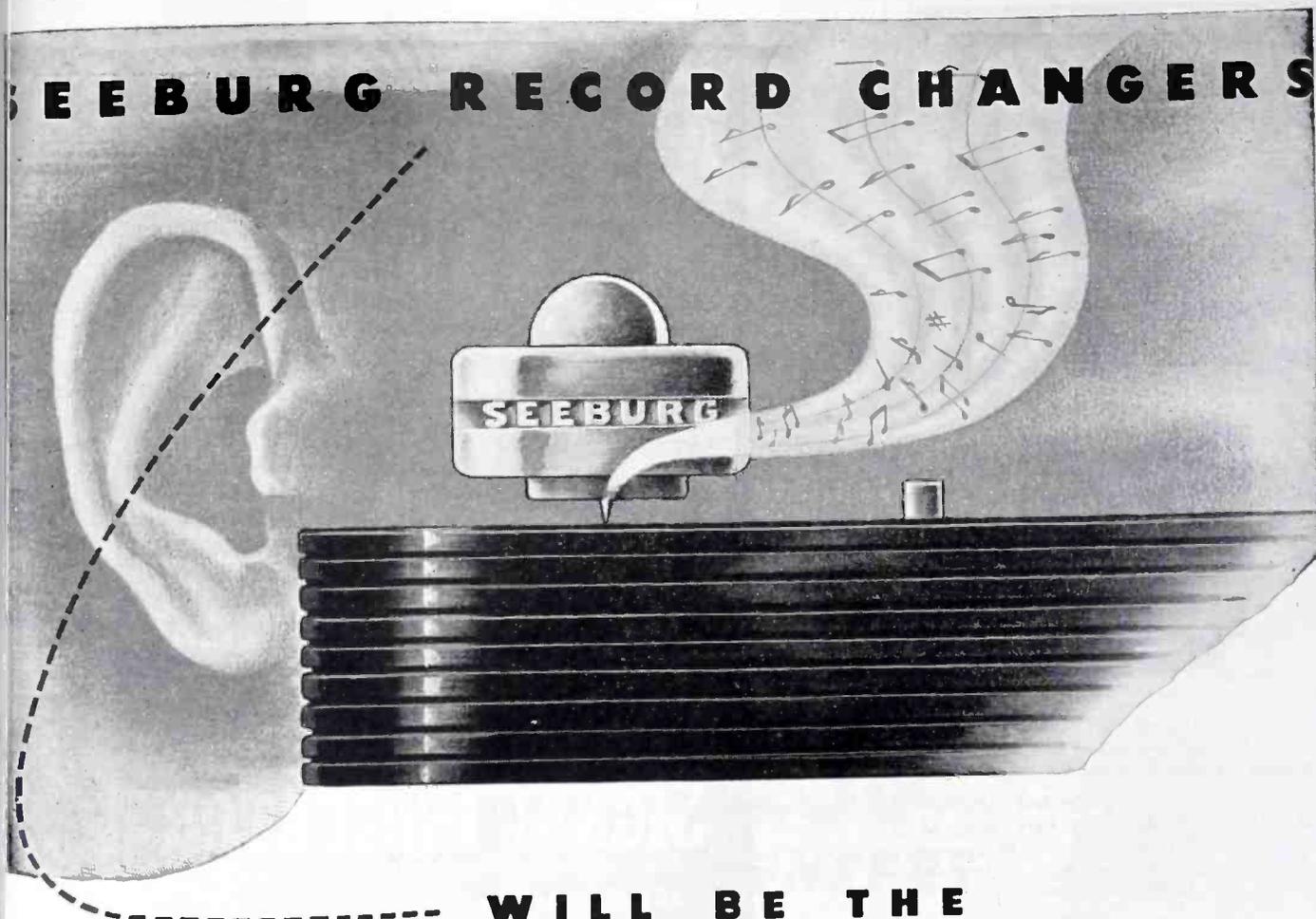


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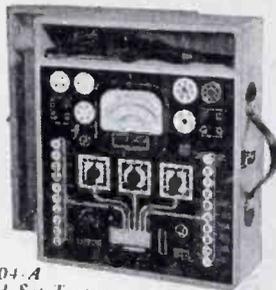
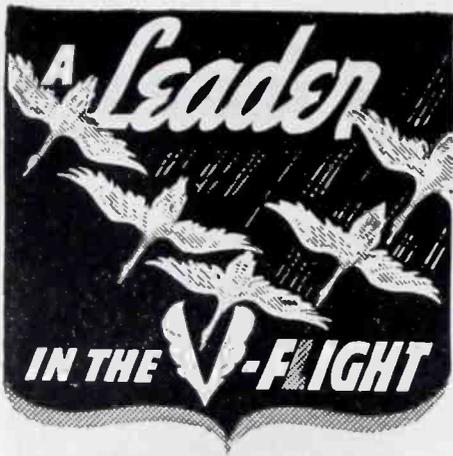
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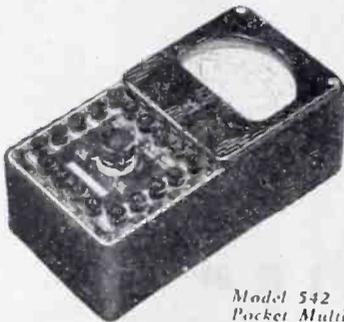
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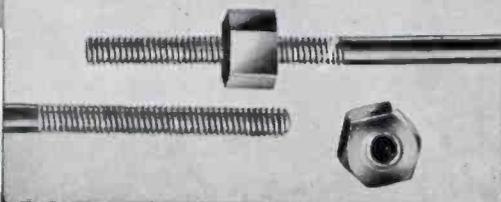
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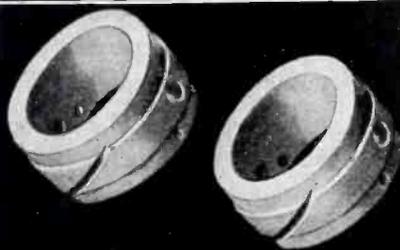
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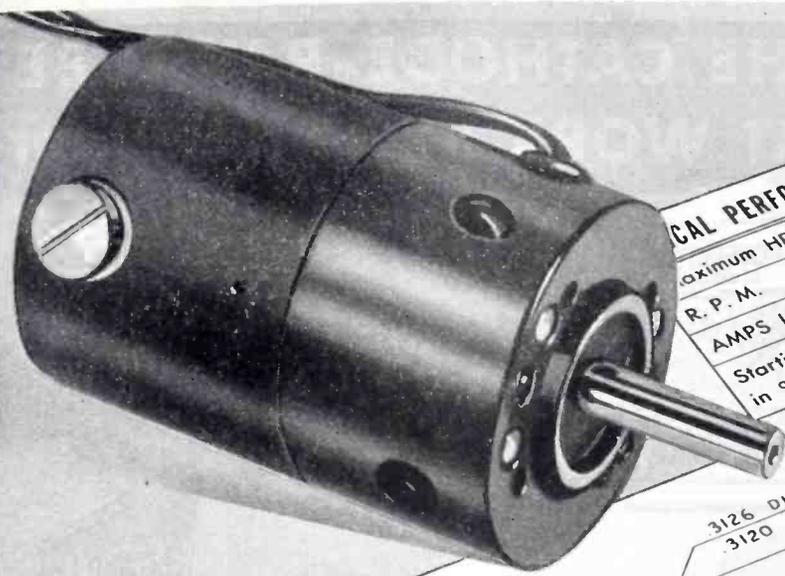
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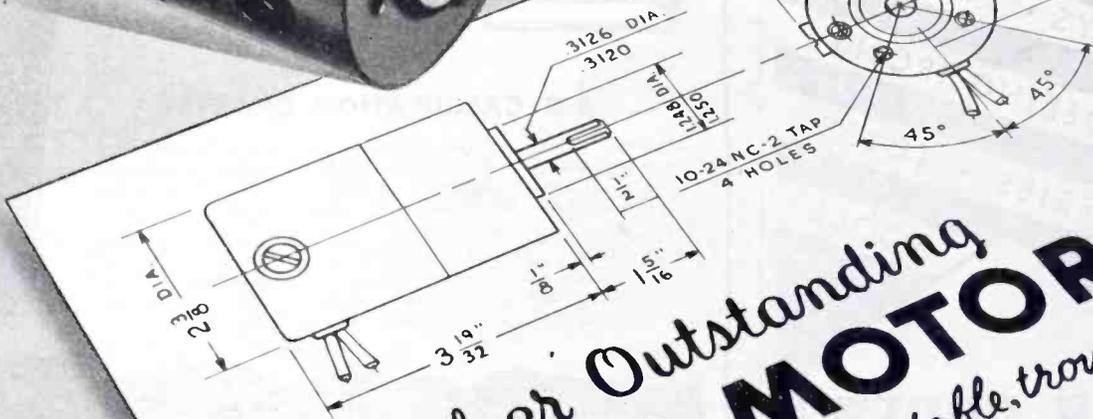
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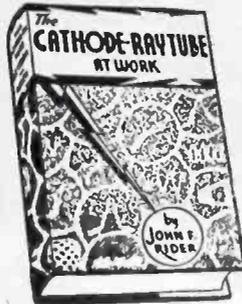
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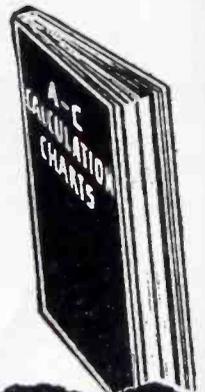
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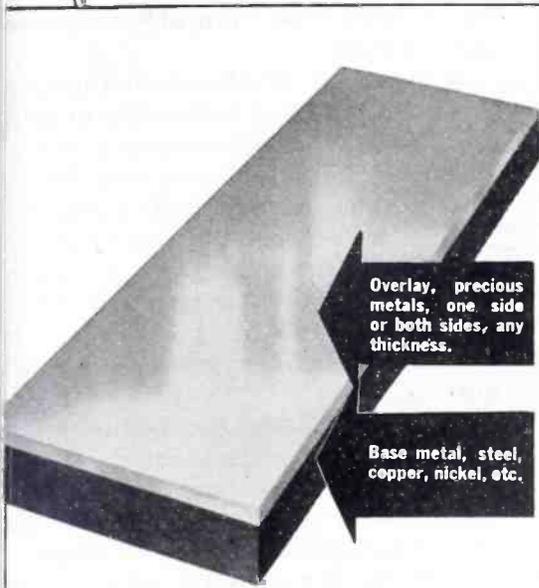
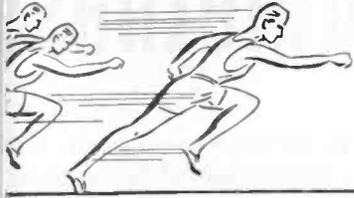
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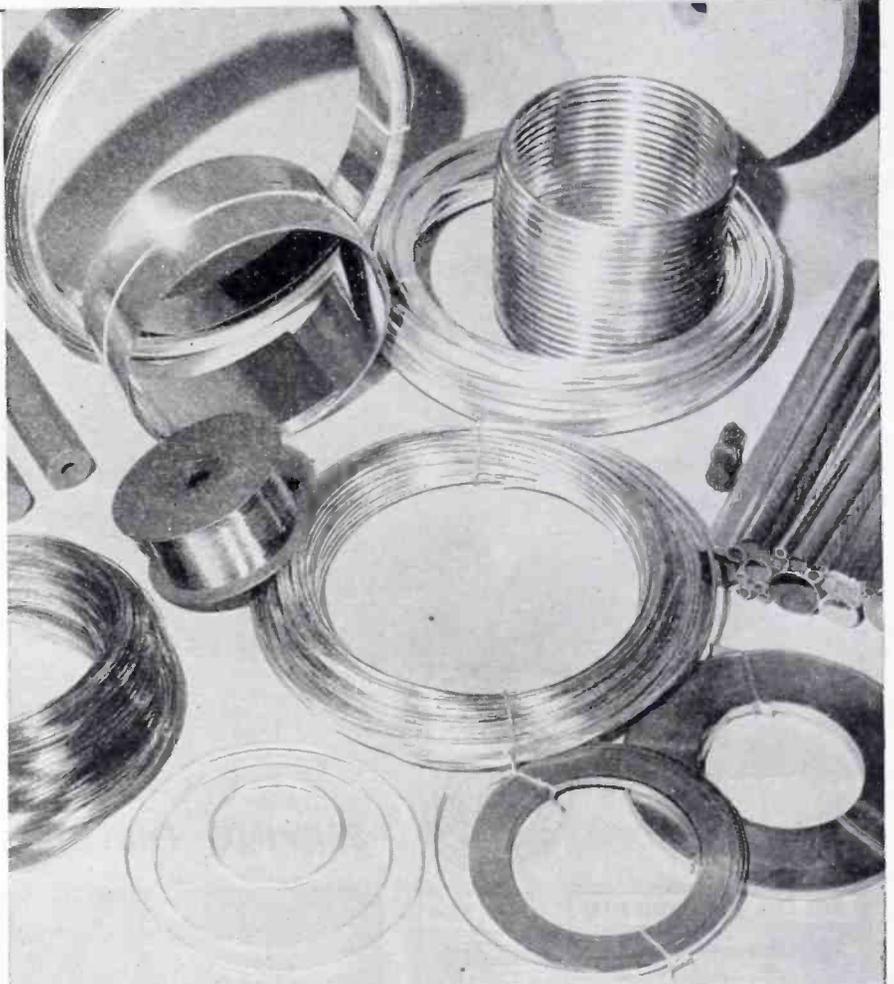
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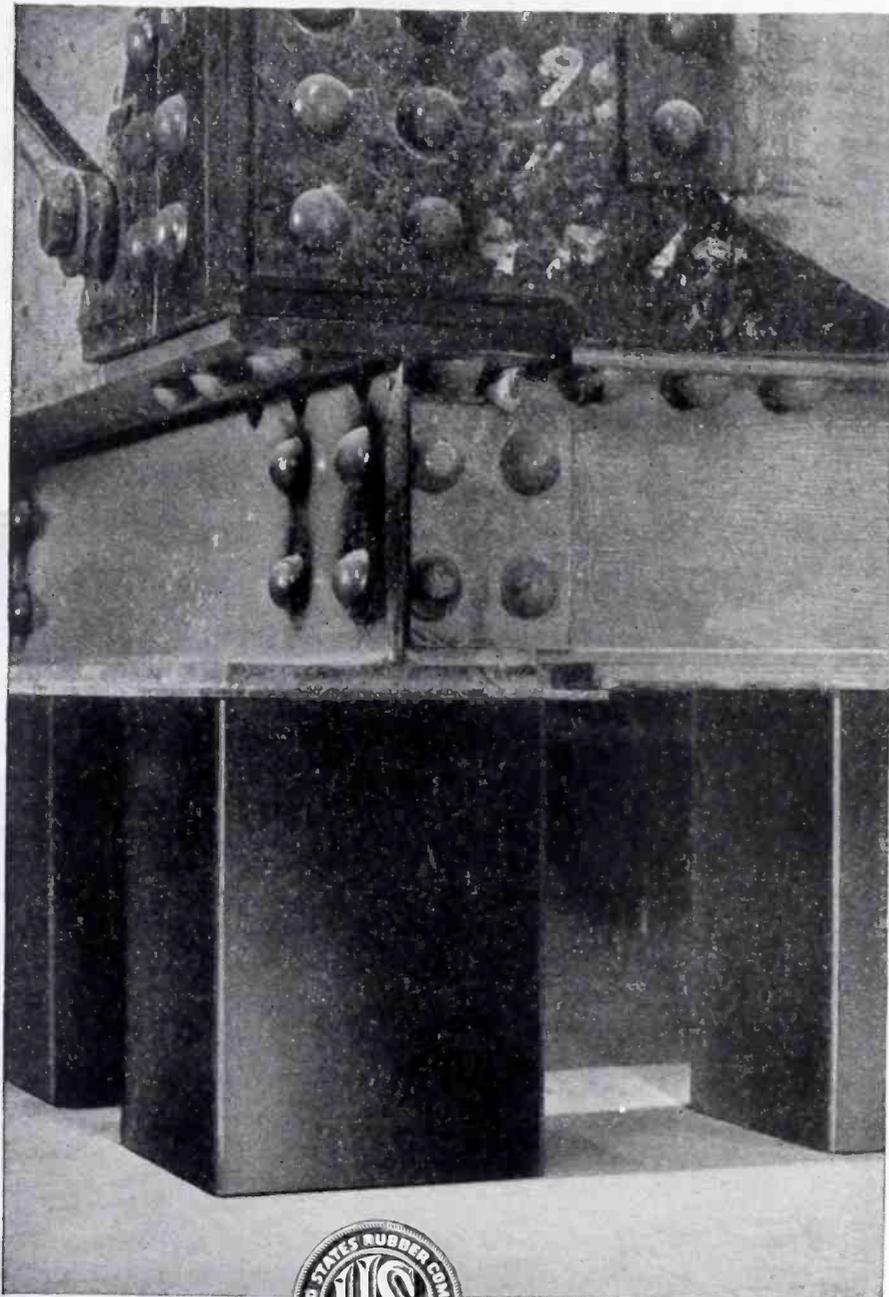
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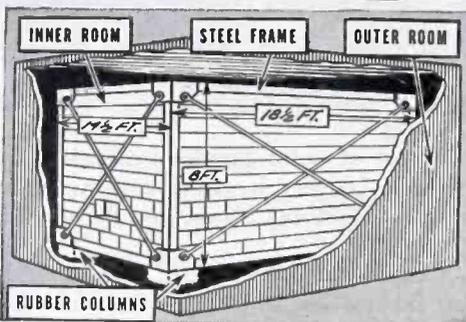
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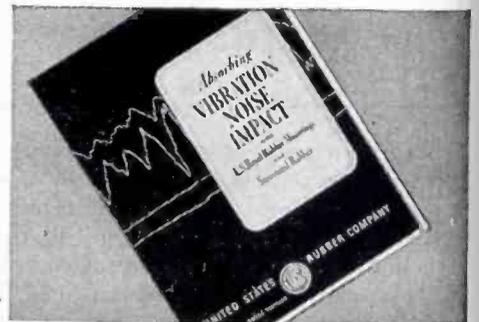
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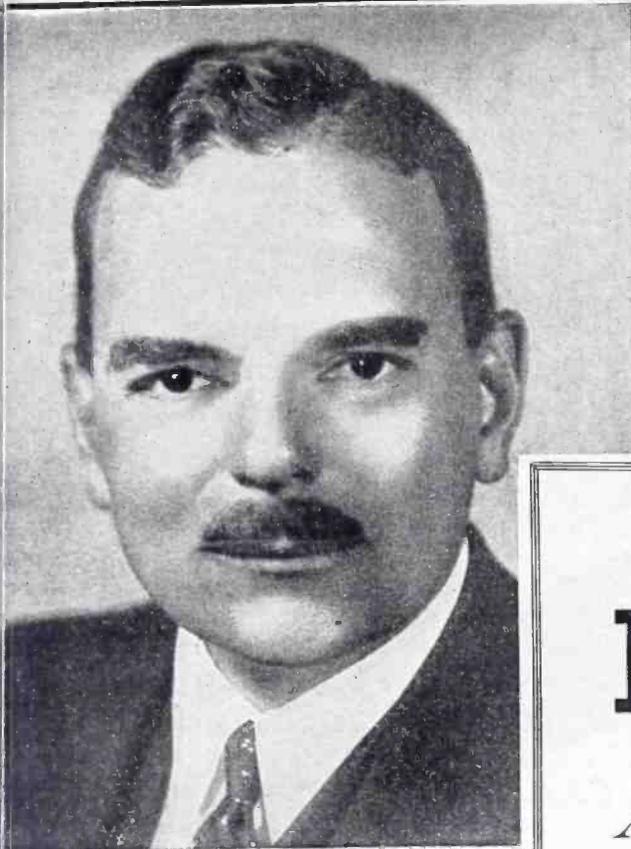
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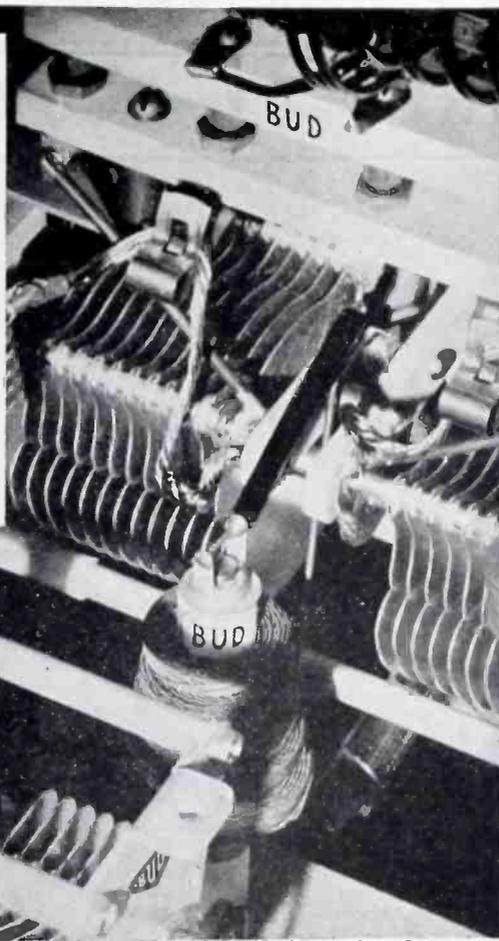
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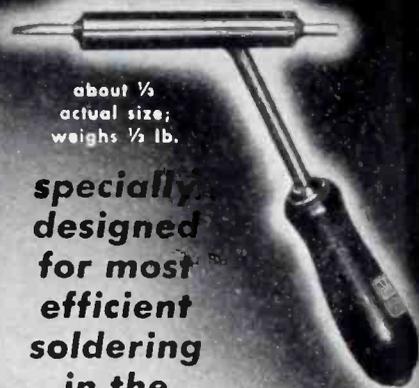
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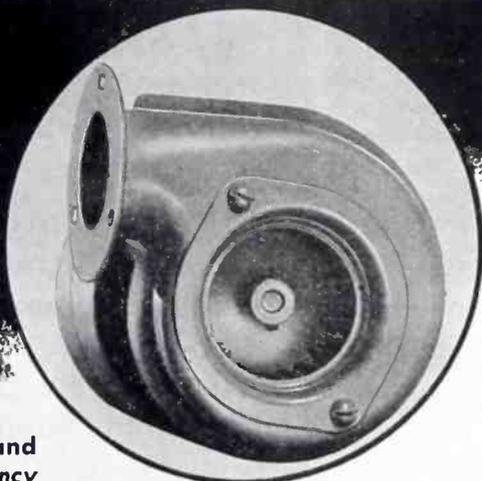
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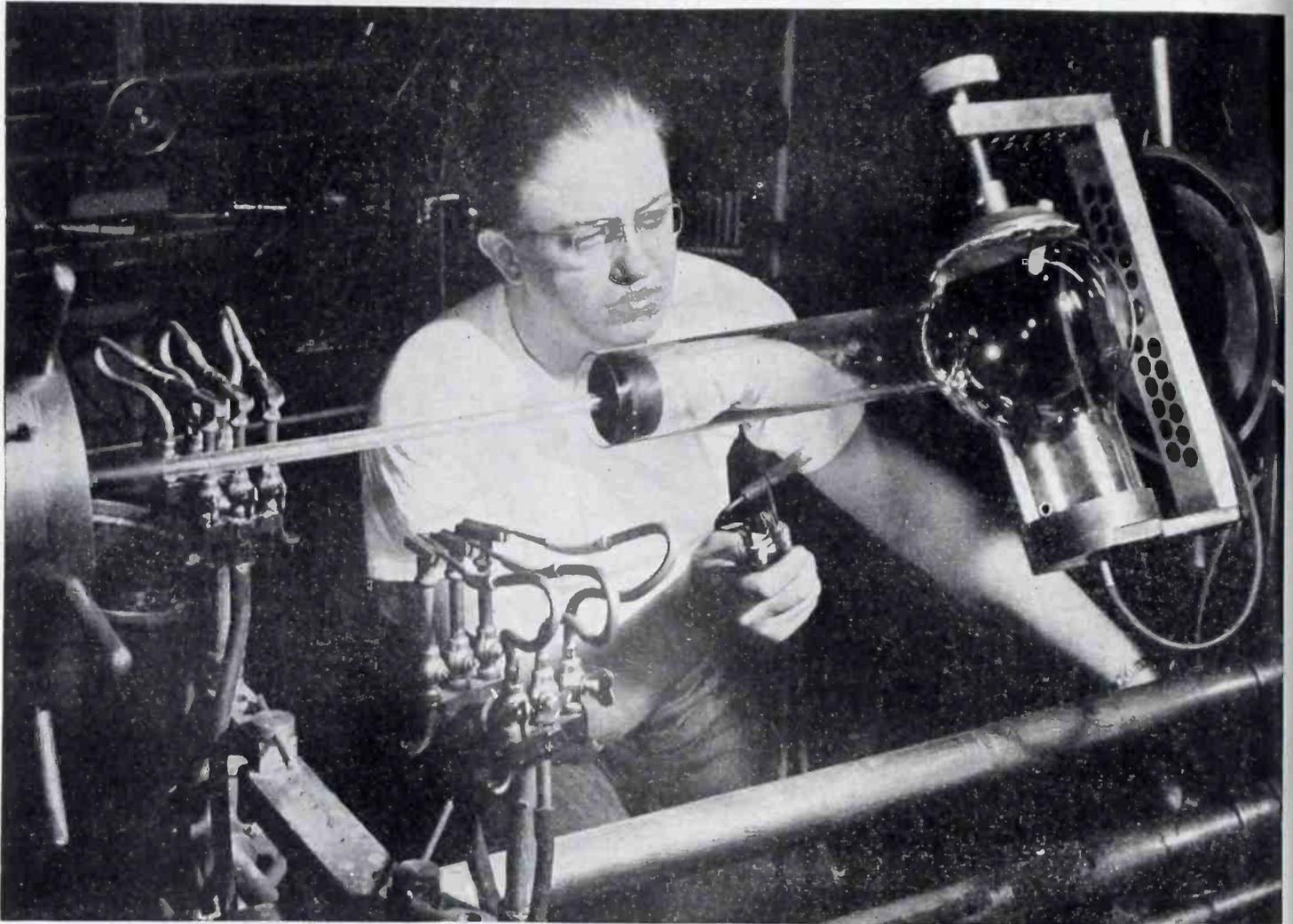


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... in Assembly and sub-assembly of Precision Electronic Products

• Complete Facilities for Production and Testing of Audio Equipment

• Consult us with your Production Assembling Problems

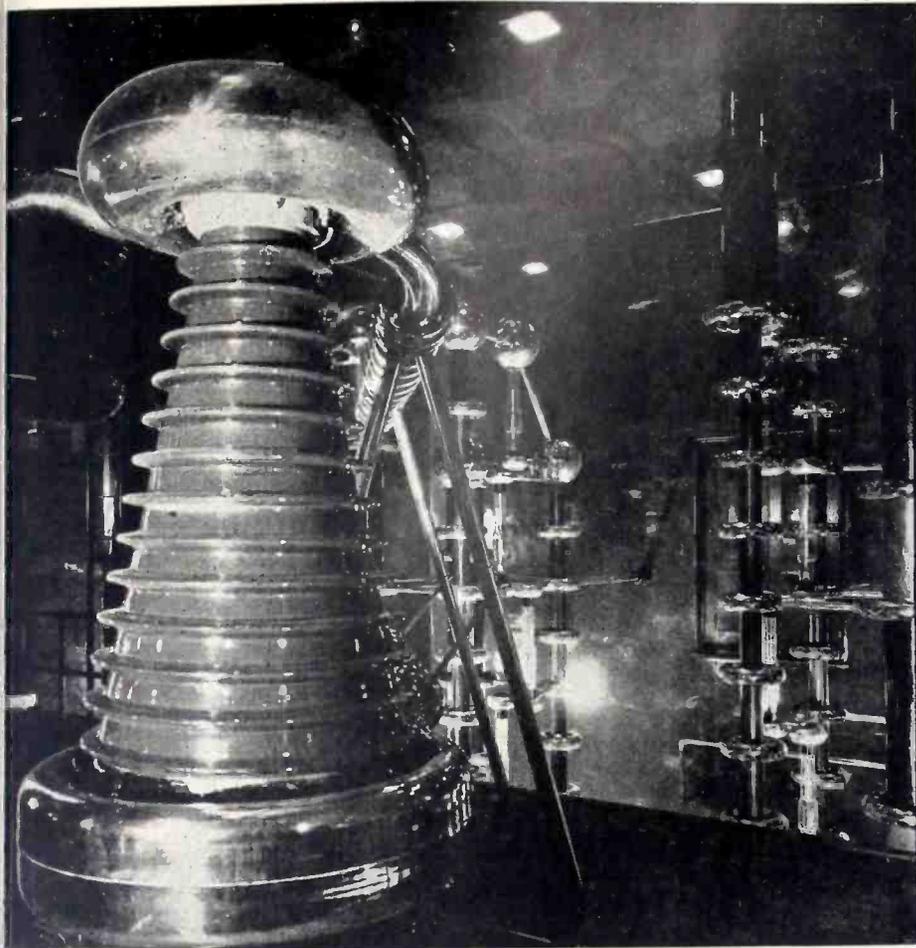
RADELL CORPORATION

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PRESTO RESISTORS
**VITREOUS ENAMEL and
 PRECISION WIRE WOUND**
 75 Winding Machines
 Backed by 20 years of Winding Experience
 ALSO
 TELEPHONE SWITCH KEYS & JACKS
 Telephone Communication
 and Cable Assemblies

PROMPT DELIVERY

PRESTO ELECTRIC COMPANY
 Manufacturers of Signalling Devices UNION CITY, N. J.



*Three years development
in three weeks...*

Years won't wait. Years ago many developments extended over periods of years and in some plants, still do.

But the tremendous amount of experience and skill that we have accumulated in the fifty years since F. M. Locke made the first wet process insulator has already laid much of the ground work that enters into every development.

Your problems may be tough and they may take longer than three weeks, but when you turn them over to us, you can be certain of this:—Our facilities for research, design and manufacturing are so comprehensive that there will be only a minimum lapse of time between the idea and the finished product.

Locke **INSULATOR CORPORATION**
" LEADERS IN CLAYRAMICS "

A COMPLETE "CLAY"RAMIC SERVICE

for every electrical, chemical and mechanical application.

Locke has unrivalled facilities for the production of fired clay pieces by every known method.

(1) Dry Process — Porcelain and Steatite

A process ideally suited to the production of certain pieces with reasonable tolerances and adequate mechanical and electrical strength.

(2) Vactite Process — Porcelain and Steatite

A process developed by Locke for forming intricate pieces. Close tolerances. Mechanical and electrical strength almost equal to wet process.

(3) Wet Process — Porcelain and Steatite

The standard process for the production of high voltage insulators, and porcelain for mechanical and chemical applications. Exceptionally strong mechanically and electrically.

Locke Wet Process porcelain and Locketite is produced by the following methods, the selection of method depending upon the piece.

- | | |
|------------------|-------------------|
| (1) Pugging | (5) Jiggering |
| (2) RamExtrusion | (6) Plastic Press |
| (3) Wet and Dry | (7) Core Casting |
| Turning | (8) Drain Casting |
| (4) Plunging | (9) Throwing |

and certain other methods which at the present have only limited application.

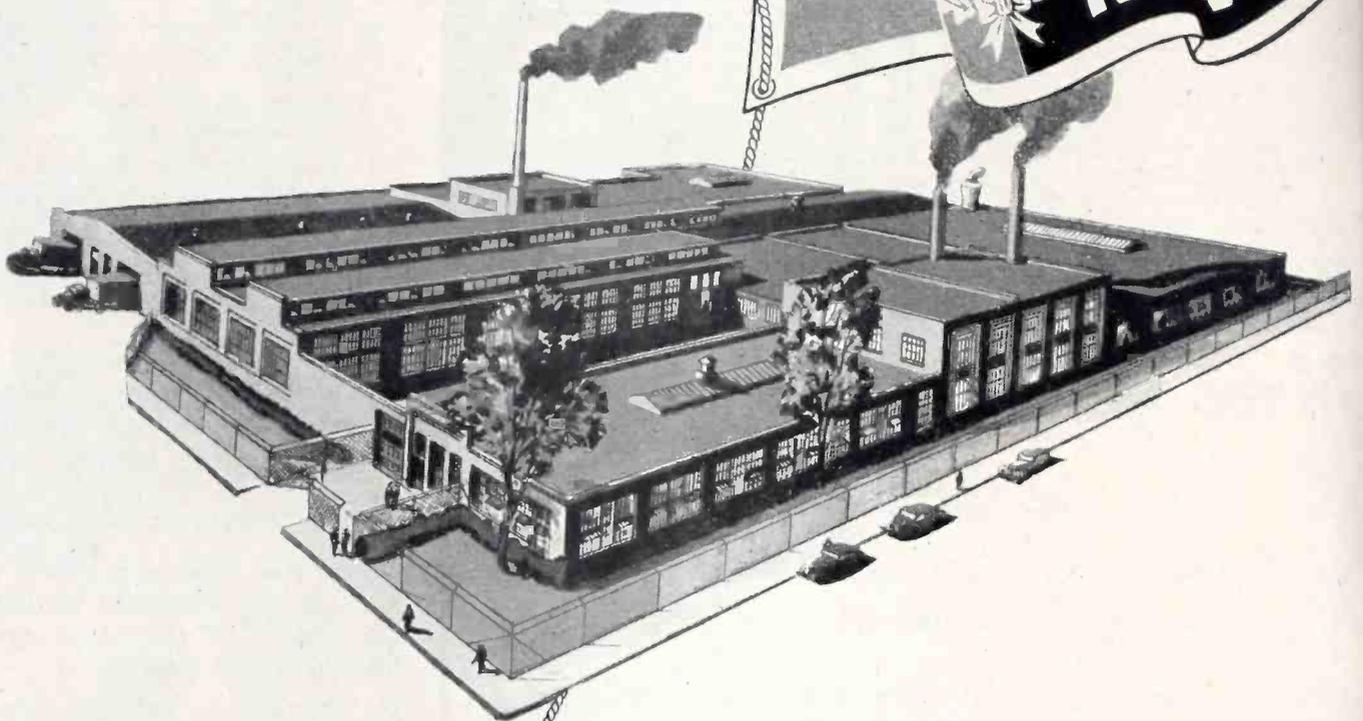
Other clayramic products will be available in the future to meet special conditions. Whatever your problem, our experienced electrical, mechanical and ceramic engineers will be glad to help. Their services have resulted in material savings in money, time and critical materials to other manufacturers. Perhaps they can help you.

**BALTIMORE,
MARYLAND**

★

PRAISE FOR JOBS WELL DONE...

Over the broad roof-tops of our plant flies the Army-Navy "E". Our workers regard it with personal pride, as a fitting reward for years of unprecedented permanent magnet production. And for our design engineers it conveys an additional meaning—recognition for their accomplishments in permanent magnet development work and for solving problems which in peacetime might not have presented themselves for decades or more.



CHALLENGE FOR TASKS TO COME

The
**INDIANA
STEEL
PRODUCTS**
Company

6 NORTH MICHIGAN AVENUE
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Specialists in Permanent Magnets Since 1910

For all of us, it is a challenge to keep our production for war mounting until Victory is won. And a challenge to utilize all we've learned to serve postwar America more efficiently and more progressively. Permanent magnets will do much to make existing products better and make new ones possible. Our 34 years of specialized experience equips us to play a leading role in this work. For help in solving your permanent magnet problems, consult our engineers. Write for a copy of our "Permanent Magnet Manual."

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THE INDIANA STEEL PRODUCTS COMPANY ★

METAPLATE PLASTIC PARTS

FOR
Shielding

FOR
Radiation

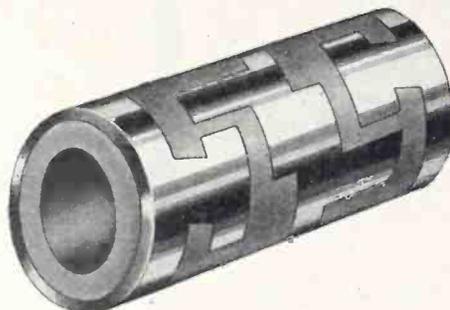
FOR
Commutation

A new, easy, inexpensive
method for combining con-
ductor and non-conductor
IN ONE PIECE

This Housing, de-
signed by Plastic
Manufacturers of
Stamford, Conn.,
for use in aircraft, is
METAPLATED for
electrostatic shield-
ing; copper with a cadmium finish
is electro-deposited on the plastic
body reducing weight and manu-
facturing time.



This Antenna Mast, fabricated by
Camfield Manufacturing Com-
pany of Grand Haven, Michigan,
is made of Compreg-Wood for
maximum strength-to-weight ratio
and is METAPLATED with copper
to provide a strong vibration-resist-
ant electrical conducting surface,
of proper shape, for maximum
high frequency radiation.



This Commu-
tator, jointly
designed by
Johnson
Service Com-
pany of Mil-

waukee, Wis., and Metaplast Company,
has intricate commutating surfaces
METAPLATED into grooves.

Metaplast

COMPANY

METAPLAST Process Patented
U. S. and Foreign Patents
TRADE MARK REGISTERED

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METAL PLATING ON PLASTICS



Since 1941 the
Metaplast Com-
pany has main-
tained a 24 hour
day schedule pro-
ducing important
war materiel.



This New Jig Speeds Your Radio Assembly

Send us your chassis or specifications for quotations. We are ready to meet your delivery schedules.

- 1) Can be loaded and unloaded in two seconds.
- 2) Indexed 360° fixture to hold chassis in any position to step up soldering and all other assembly operations.
- 3) Adjustable to any size to base limits of the Jig. Comes in various sizes or we will make jigs to your chassis or specifications.
- 4) Sturdy, rigid construction.
- 5) Holding adapters to fit your chassis.

ROBERT L. STEDMAN MACHINE WORKS
 SPECIALISTS IN MASS PRODUCTION TOOLS
 OYSTER BAY, LONG ISLAND NEW YORK



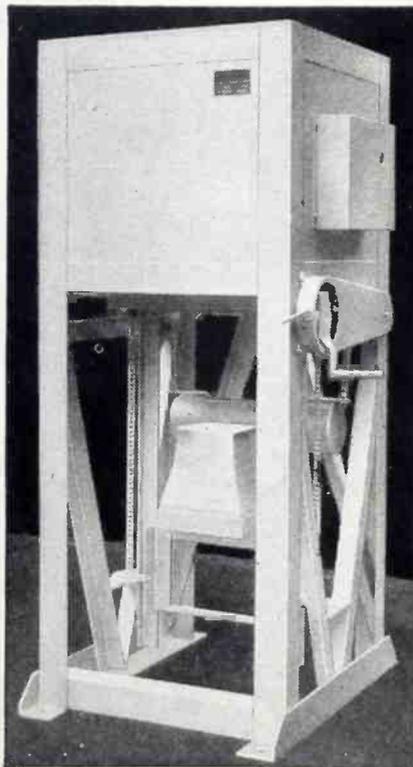
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Electric Furnaces
 1500°-2950°F.
 TEMPERATURE RANGE

Materials to be heated are placed on a refractory slab and elevated into the furnace by a convenient, counter-balanced lifting mechanism. A controlled heating and cooling cycle is obtained by controlling power input during heating period, and by controlling circulation of air through the heating chamber during the cooling period.

Protective atmosphere can be obtained by placing a closed-end cylindrical muffle on the refractory slab and introducing a gas into it through an inlet in the hearth. Temperature inside the muffle can be measured by extending a thermocouple up through the hearth slab.

When melting in a crucible, a plug at top of furnace is removable for making additions, stirring, or carrying off fumes when heating glass or special alloys.



HARPER Electric FURNACE CORP.
 1463 Buffalo Ave., Niagara Falls, N. Y. Incorporated 1924

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RADIO ANTENNAS

In Standard and Special Designs are performing a vital service for the Allied Military Forces in maintaining communications under the most trying conditions.

WATCH
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RADIO ANTENNA

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Division Chisholm-Ryder, Co., Inc.
 4502 Highland Ave., Niagara Falls, N. Y.

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 ALL SIGNAL CORP ORDERS BEARING
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All R.M.A. or A.S.A. color coded
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 to 5,000 of each capacity in regular MICA
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MATURE EXPERIENCE and JUDGMENT



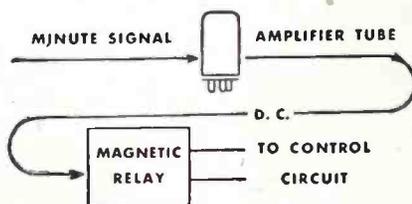
in Industrial Electronic Applications

Many years before "Electronics" blossomed as the wonder child of a postwar world, United Cinephone Corporation Engineers were putting Electronic devices to work for industry; devices which were practical, rugged, and down-to-earth.

Experience has shown that the solution of problems in Industrial Electronics usually requires the merging of Mechanical engineering with Electronic engineering to the fullest extent possible.

United Cinephone engineering and production facilities have proved valuable in many important industrial plants in connection with product control, automatic machine operation, operator safety and simplification of manufacturing methods.

Our engineers will welcome your inquiry. It will have every attention consistent with our responsibilities as Prime Contractors in the manufacture of military electronic equipment.



Model ES-15

- **ELECTRONIC SWITCH:** For reliable switching where a tiny current can replace heavy currents or mechanical devices. Only $3/1,000,000$ ampere will actuate the electron tube which operates the relay.



UNITED CINEPHONE CORPORATION

TORRINGTON, CONNECTICUT

WHY CONSULT SIGMA?

IF

any relay that works at all is good enough for your job . . . if you are not interested in

- Compactness
- Fast operation
- Precise timing
- Exceptional sensitivity
- Performance in difficult environment
- Maintenance of operate values within narrow limits



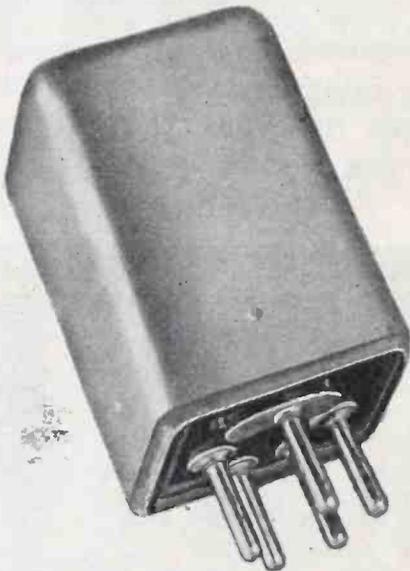
Then there is no reason to pick out Sigma from among the many competent relay manufacturers.

IF

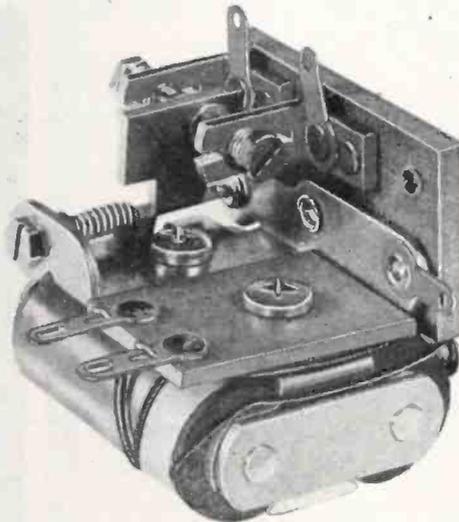
on the other hand, your requirements are stringent and must be fulfilled exactly, you will be interested in Sigma's method of operation.

We do not in general sell "stock" or "standard" items, even though our relays are all assembled from standard parts. Your problem is studied in detail by our engineering staff. Experimental work is done if necessary. Decisions are then made as to just what can be achieved. Then, when agreement with your engineering department on what is to be expected from the use of our relays is complete . . . we accept your order.

Our guarantee does not stop with "faulty workmanship or defective materials," but includes performance up to the end result intended.



TYPE 5RH
Hermetically Sealed
(1 1/2" x 1 1/2" x 2 1/4")



TYPE 5FMD
Make-Delay 0.2 Sec. Input
.020 Watt For Aircraft Service

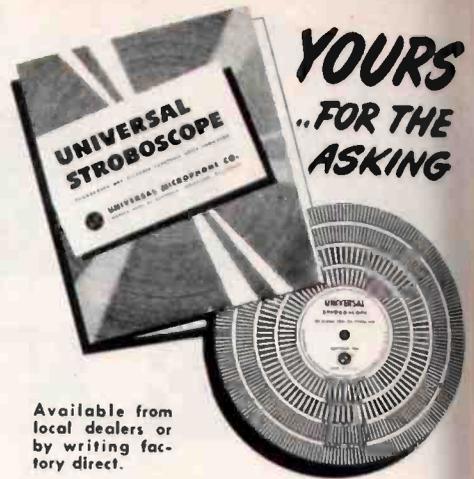


Sigma Instruments, Inc.

Sensitive RELAYS

NEW ADDRESS

62 CEYLON STREET
BOSTON 21, MASS.



**YOURS
..FOR THE
ASKING**

Available from local dealers or by writing factory direct.

UNIVERSAL STROBOSCOPE

This handy phonograph turntable speed indicator, complete with instructive folder, is now available gratis to all phonograph and recorder owners through their local dealers and jobbers. As a recorder aid the Universal Stroboscope will assist in maintaining pre-war quality of recording and reproducing equipment in true pitch and tempo. Universal Microphone Co., pioneer manufacturers of microphones and home recording components as well as Professional Recording Studio Equipment, takes this means of rendering a service to the owners of phonograph and recording equipment. After victory is ours—dealer shelves will again stock the many new Universal recording components you have been waiting for.



UNIVERSAL MICROPHONE CO.
INGLEWOOD, CALIFORNIA

110-VOLTS A. C. from DIRECT CURRENT

with KATOLIGHT ROTARY KONVERTERS for operating radio and electronic equipment, moving picture projectors, sound apparatus, A.C. appliances, etc.



225 WATT
KONVERTER

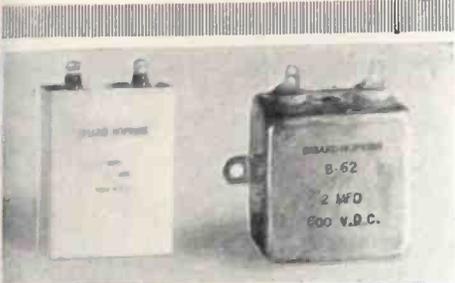
Available in sizes 110 through 2500 watts, 1800 and 3600 r.p.m. ball bearing designs. Furnish standard 110-volt 60 cycle A.C. from 32, 110 or 220-volts direct current. Quiet in operation. Can be furnished with special filtering equipment for sensitive radio work.

PIONEERS IN THE BUILDING OF SMALL ROTARY CONVERTERS

At present Kato's entire production must be directed to furnishing converters on high priority orders. Wire us if you need this kind of equipment for orders.

Also manufacturers of A.C. and D.C. generators ranging from 350 watts through 25 K.W.; power plants; Frequency changer; high frequency generators; and Motor Generator Sets.

KATO ENGINEERING CO.
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STANDARD or SPECIALLY DESIGNED

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For the past 15 years Girard-Hopkins have built standard and specially created capacitors, designed to meet the most exacting climatic and technical conditions. Our line includes every stock type of capacitor for normal needs — Increased manufacturing capacity and a highly trained engineering staff enable us to quickly build and deliver specially designed capacitors to your specifications. Consult us on your present and post-war capacitor problems for either wax or oil types.

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Now you can
bring your Radio-
Electronic knowledge
UP-TO-DATE

—quickly, at home

Are you getting a little rusty on the fundamentals of Radio and Electronics - or feel you are slipping behind in your knowledge of today's fast moving Radio-Electronic developments? Or perhaps you are seeking an honest-to-goodness, practical training in Radio-Electronics - knowing that men who have worked themselves up to good jobs in this industry are still studying, experimenting - with their eyes on bigger jobs and more pay - or a business of their own in one of postwar's most promising opportunity fields.

In any event, we believe you will be very much interested in considering the advantages of our modern course of instruction prepared under the supervision of Dr. Lee DeForest - and which includes such effective home study aids as "Learn-by-Seeing" movies, to help clear up important fundamentals, and eight kits of "Learn-by-Doing" Radio parts and assemblies, permitting 133 Radio-Electronics experiments in your spare time. Mail coupon today for complete information. No obligation.

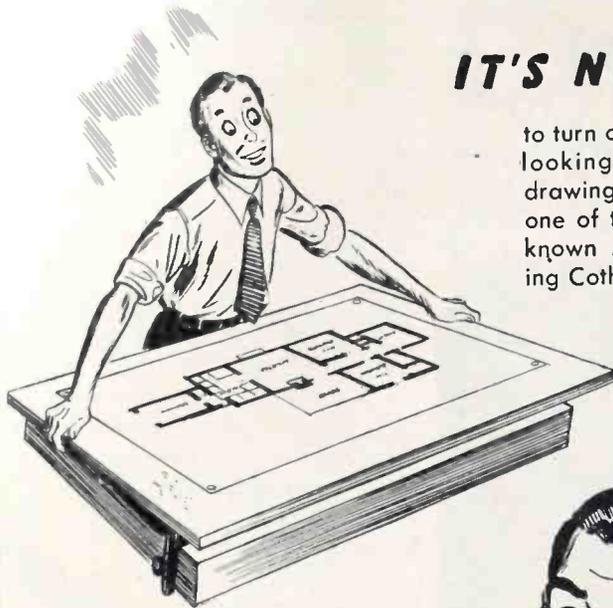
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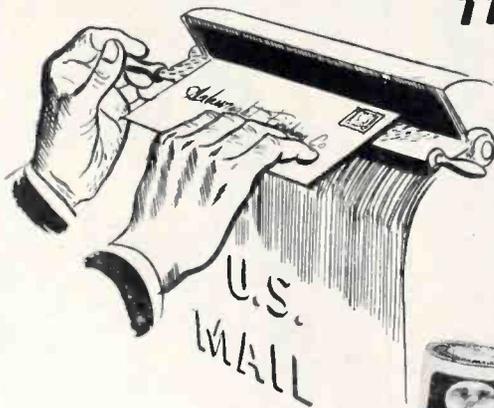
to turn out professional-looking, neat-as-a-pin drawings fast with any one of the four widely-known Arkwright Tracing Cloths.

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AMERICA'S STANDARD FOR OVER 20 YEARS

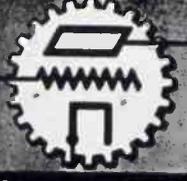
**SAFE
AND SANE**
*Voltage Breakdown
Testing*



- Range: Model P-3 here shown, 0-10,000 v. D.C., 0-8,000 v. A.C. Model P-1, smaller, sloping panel, 0-4,000 v. D.C. P-2 has added 3,000 v. A.C. outlet.
- Continuously variable voltage over entire range.
- Operates directly from 110-130 v. 50/60 cycle A.C. line. Panel light indicates "On."
- Breakdown indicated by red signal light. Built-in meter indicates direct-reading voltage.
- Uniform maximum current 5 milliamperes on P-1, 50 milliamperes on P-3 over entire voltage range.
- Fine-grained cracked-enamel metal cabinet, 15" x 21" x 28" H.

• Simple, positive, safe and quick means of testing voltage breakdown of materials or components. Safety switch makes power supply inoperative if chassis is removed from cabinet. To speed up production testing, with absolute safety, drawer-switch test fixtures are available. Typically an "Industrial Instrument."

• Write for Bulletin . . .

Industrial 	PLANT and OFFICES:
	17 POLLOCK AVENUE
	JERSEY CITY 5, N. J.
Instruments:	



ZOPHAR Fungus-Proofed Waxes

As a vital service to the Armed Forces we now offer Fungus Resistant Materials. These recently developed products are the answer to Communications requirements where the impregnation or coating of radio parts and equipment are concerned.

ZOPHAR waxes and compounds meet every specification of both the Army and Navy for waterproofing and insulating all electrical and radio components. They also have wide application in packaging of every description.

ZOPHAR MILLS I N C

112-130—26th STREET ESTABLISHED 1846
BROOKLYN, N.Y.

DESIGNED FOR DISCRIMINATING MANUFACTURERS



Leakproof

ENAMELED MAGNET WIRE

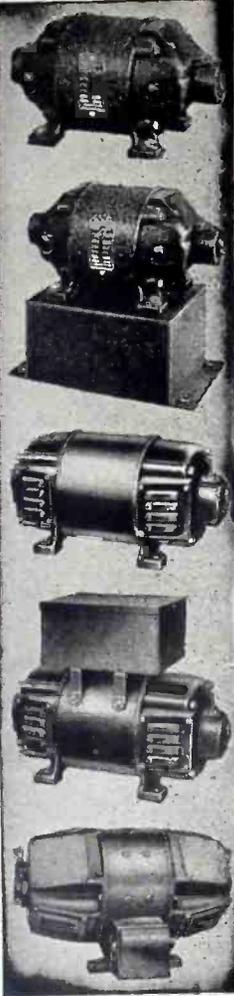
A product, resulting from many years of research in the field of fine wire manufacture, that meets the most rigid requirements of radio and ignition coils. A new coating method gives a smooth, permanently-adherent enameling, and mercury-process tests guarantee perfect uniformity. Great flexibility and tensile strength assure perfect laying, even at high winding speeds. If you want reduction in coil dimensions without sacrificing electrical values, or seek a uniform, leakproof wire that will deliver extra years of service, this Hudson Wire product is the answer.

Also manufacturers of high grade cotton and silk covered wires, cotton and silk coverings over enamel coated wires, and all constructions of Litz wires. A variety of coverings made to customers' specifications, or to requirements determined by our engineers. Complete design and engineering facilities are at your disposal; details and quotations on request.



Winsted
HUDSON WIRE CO.
Division
WINSTED • CONNECTICUT

CONVERTERS



Janette
D.C. to A.C. CONVERTERS

UP
TO 3.2
K.V.A.

When only D. C. power is available, ELECTRONIC DEVICES requiring from 110 to 3250 volt-amperes A. C., can be operated by a rugged Janette rotary converter. Many thousands of such essential safety and other electronic devices, used on ships and shore stations, depend upon Janette converters for power.

Wherever there are ships, you will find Janette converters.

Janette

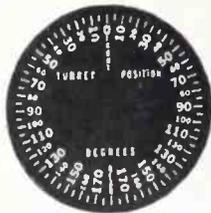
Janette Manufacturing Co. · 556-558 W. Monroe St. · Chicago, Ill.

New INLAY PROCESS

ELIMINATES NAME PLATES ON FRONT PANELS

A proven method for placing durable characters on metal panels, chassis, etc.

- ★ Inlaid baked enamel characters, protected by background finish; resistant to abrasion and salt spray; guaranteed to pass 50 hour salt spray test.
- ★ Front panel will match finish of cabinets.
- ★ Recommended and endorsed by scores of manufacturers of electronic, sound and communication equipment.

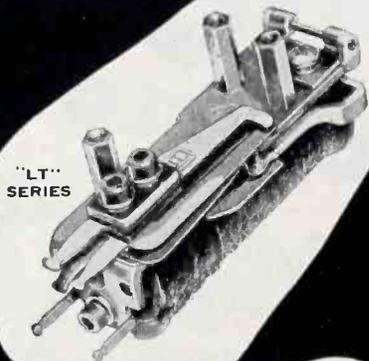


PROMPT DELIVERIES—Send us your bare fabricated steel and within two weeks we will return it finished and marked to your complete satisfaction.

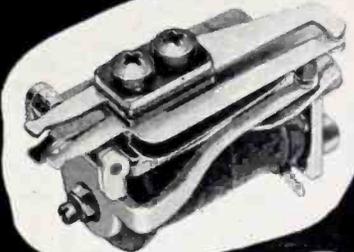
SCREENMAKERS
64 FULTON STREET · NEW YORK 7, N.Y.
Tel.: REctor 2-9867

ALSO...
SILK SCREENING on front panels and chassis, either metal or plastic. Sharp clear characters durably printed on finished or unfinished surfaces.

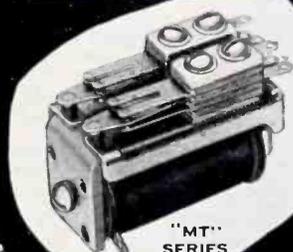
TELEPHONE RELAYS



"LT" SERIES



"ST" SERIES



"MT" SERIES

POTTER & BRUMFIELD

Potter & Brumfield are now manufacturing a complete range of high grade telephone relays.

Excellent construction features guarantee maximum efficiency for any use.

Available for operation on direct current—wide variety of contact combinations—coils available for operation up to 220 volts.

Write for prices and complete specifications—also catalog covering other standard relays.

Potter & Brumfield

Mfg. Co., Inc.

105 North 10th Street, Princeton, Indiana

Another **NEW** **JOHNSON** DEVELOPMENT

Rubber Drain Connector

ELIMINATES COST OF CASTINGS. Here is a new Johnson rubber drain connector that invades the washing machine field, antiquating the old fashioned zinc die casting drain.

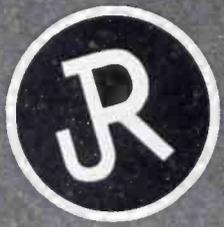
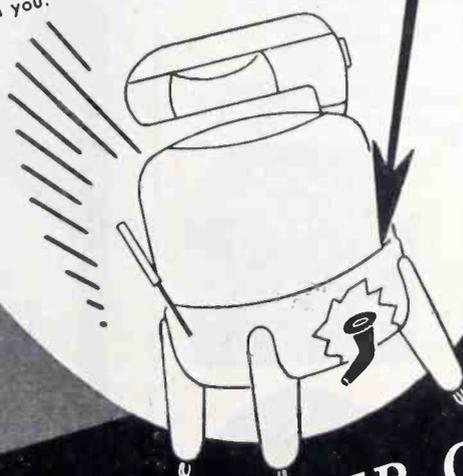
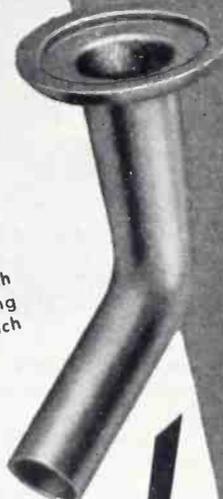
LARGER OPENING — FASTER DRAINING. A one inch opening for instance in place of the standard $\frac{3}{4}$ " casting opening. Faster, yes, a great deal faster drainage which will please any housewife.

ABSORBS VIBRATION. Made of rubber they are flexible, absorb vibration, prolonging the life of the machine, also silencing rattles and noises.

COST LESS. Johnson's Rubber Drain Connectors are better and more practical units at considerable less cost and can be made to conform to any type of shutoff valve, or to connect with any type of pump, in any shape or length.

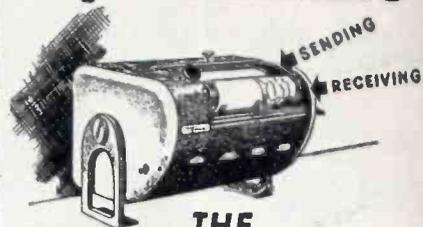
EASIER — FASTER TO INSTALL. Installation costs are lower because they require less time, less effort and work this . . . no tools. This "no tools" means the end to chipping and marring of enamel, resulting in more firsts fewer seconds.

Johnson's Drain Connectors have many applications. Perhaps with a few changes they can be adapted to your requirements. Whatever your problem, be it difficult or easy, we welcome the opportunity of working with you.



The **JOHNSON RUBBER CO.**
MIDDLEFIELD, OHIO
MOLDED & EXTRUDED RUBBER PARTS FOR
INDUSTRY'S VITAL ASSEMBLIES

finch facsimile



THE "INSTANT COURIER"

(Transmits pictured messages by radio or wire)

★
For the present, Finch manufacturing facilities are being devoted to special radio apparatus for . . .

- U. S. SIGNAL CORPS
- U. S. NAVY
- U. S. ORDNANCE DEPT.
- F. C. C.
- F. B. I.
- U. S. TREASURY DEPT.
- and WAR MANUFACTURERS

FINCH
TELECOMMUNICATIONS, Inc.
PASSAIC, N. J.

KIRKLAND Pioneer INDICATING LAMPS

New

D/E DOME TYPE LENS-CAP WITH HEAVILY WALLED, DEEPLY CUPPED GLASS LENS. SO OUTSTANDING THAT A COMPLETE LINE OF PILOT-LIGHTS HAS BEEN EQUIPPED WITH IT.

For Use With the Most Readily Obtainable Lamp Bulbs

Type No. 590 D/E Unit for use with the S6 candelabra screw base lamp on voltages up to 120 volts.



The No. 590 D/E Unit, List Price, (less lamp) \$1.25.

Specifications: Mounting hole, $\frac{7}{8}$ " diameter; overall depth behind the front of the panel $\frac{3}{4}$ "; length of threaded area $1\frac{1}{16}$ ". Underwriters' Approved.

Distributed Nationally by
GRAYBAR ELECTRIC CO.
Write for
Catalogue

THE H. R. KIRKLAND CO.
MORRISTOWN, N. J.

INDUSTRY GETS GREEN LIGHT

H. P. Segel Co. Set To Aid Reconversion

Boston, Sept. 24—Representing manufacturers in New England for over 19 years, the Henry P. Segel Co. of Boston, Mass., Field Engineers and Manufacturers Representatives, offers intelligent service to manufacturers now planning post war models.

The first manufacturers representatives to nationally advertise their service, this forward-looking organization has a long record of helping leading industrials in the radio and electronic fields keep ahead of competition. Investigate this opportunity to give your business the right kind of representation at this crucial time

HENRY P. SEGEL CO.

Manufacturers Representatives
Field Engineers

221 Columbus Ave., Boston 16, Mass.
Telephones KENmore 3012-6333
Branch Office in Hartford, Connecticut



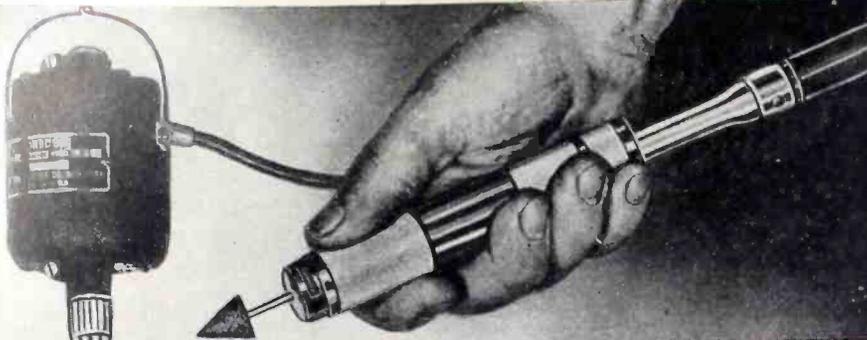
After The Others Failed ..

SpeedWay's "know how" was able to develop new special design for the Armed Forces that did the required job. Today, expanded needs for these motors take SpeedWay's capacity, as well as the capacity of other large motor manufacturers, working to SpeedWay Specifications.

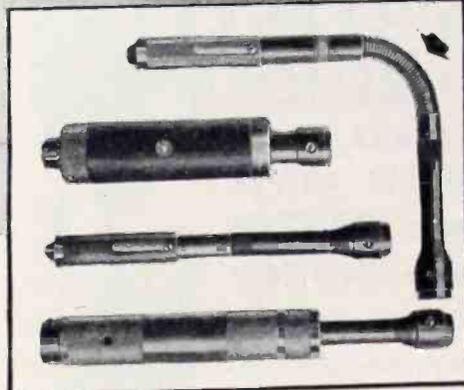
If you need motors or gearmotors for a standard or special application bring your problem to SpeedWay. Motor outputs range from 1/3000 to 1/3 h.p. Unlimited gear ratios available from stock gears. Write for our recommendations on your war or postwar problem.

Write for SpeedWay's new Motor Bulletin showing standard A.C., D.C., and Universal Motors and generators.

SPEEDWAY MANUFACTURING CO.
1898 S. 52nd Ave., Cicero 50, Ill.



Choice of
AMERICAN INDUSTRY
for DE-BURRING and
LIGHT GRINDING
and FINISHING JOBS



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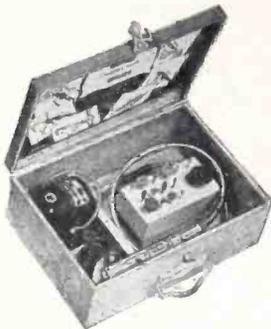
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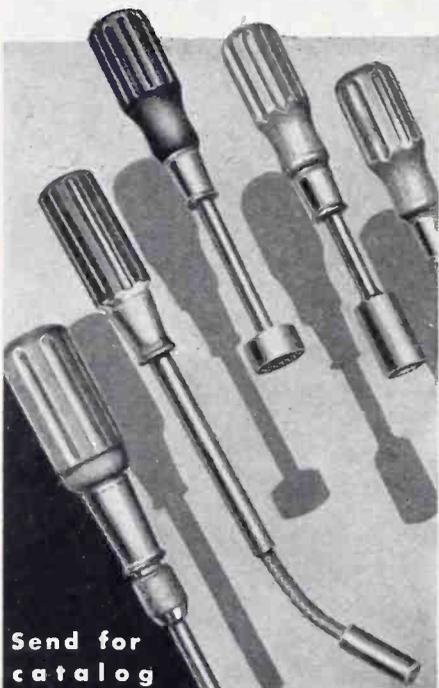


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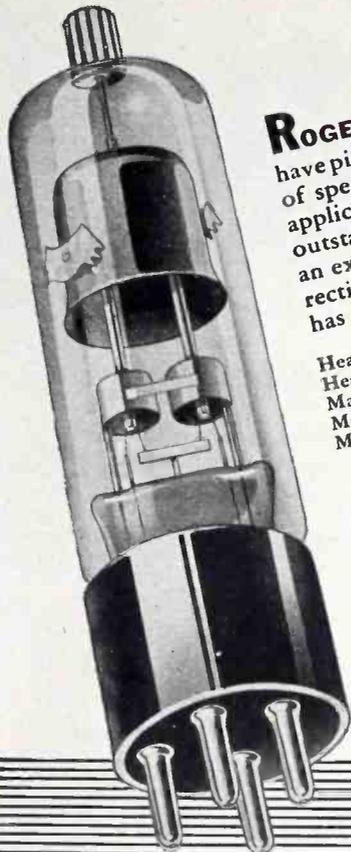


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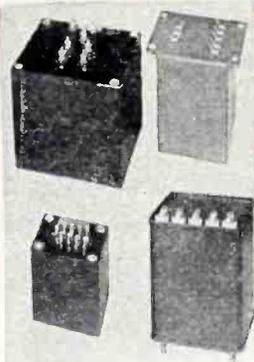
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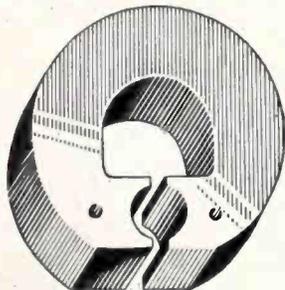
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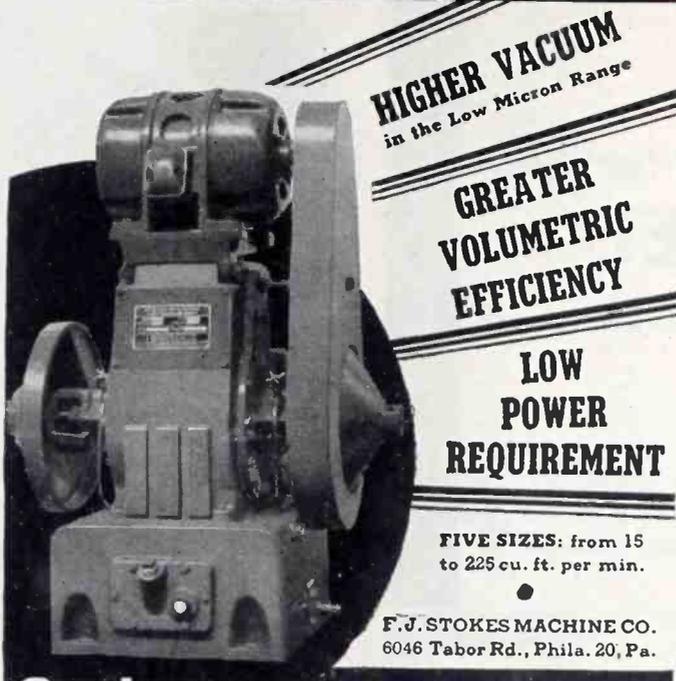


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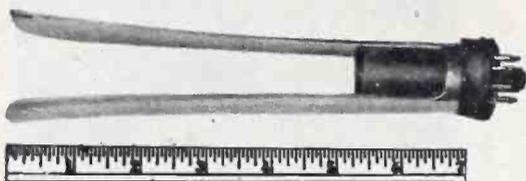
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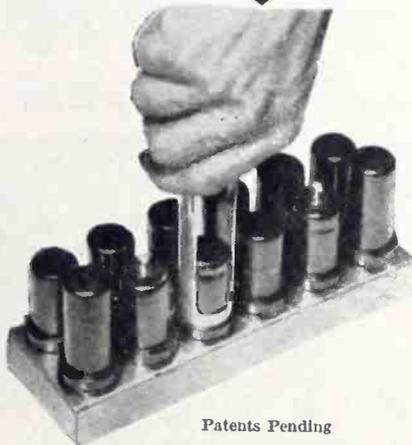
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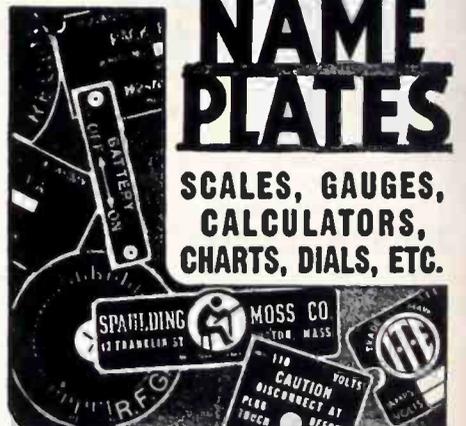
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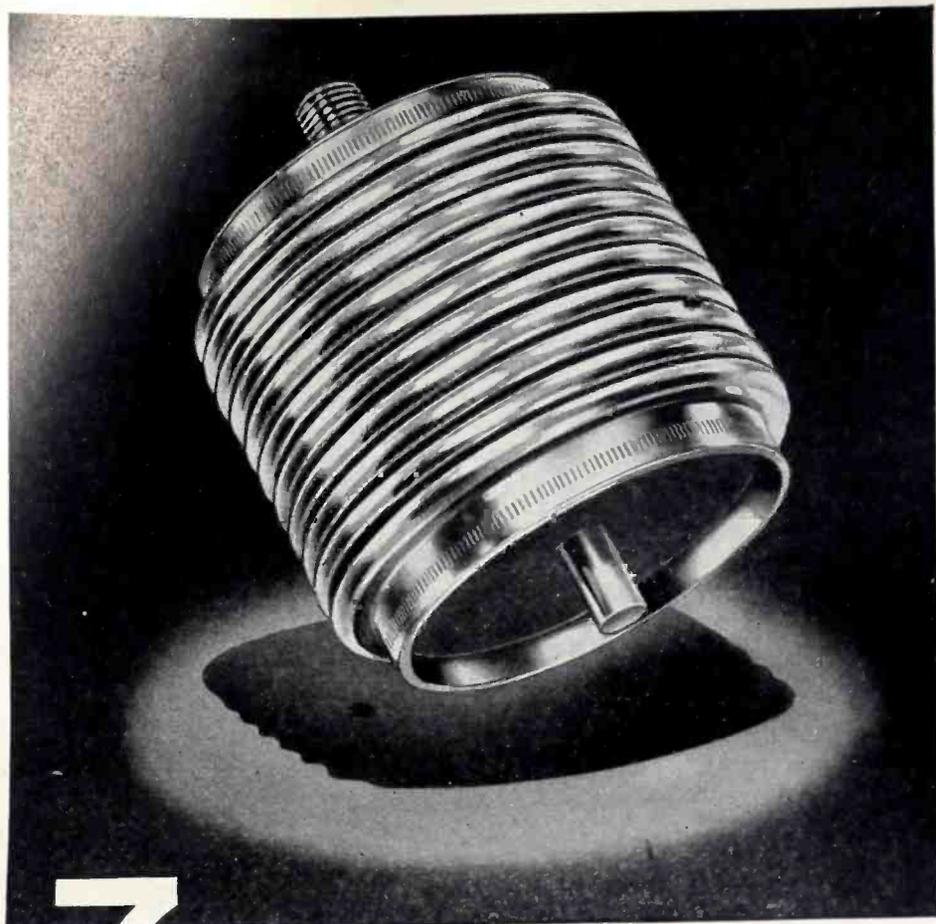


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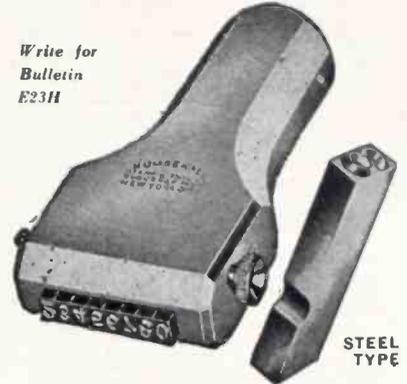
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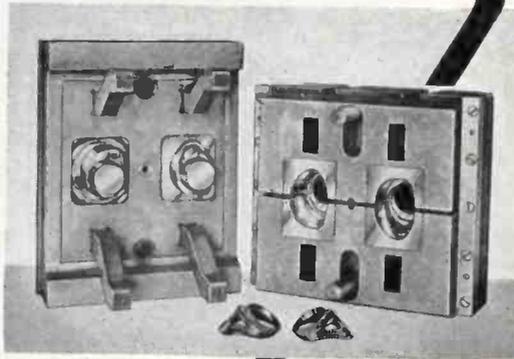
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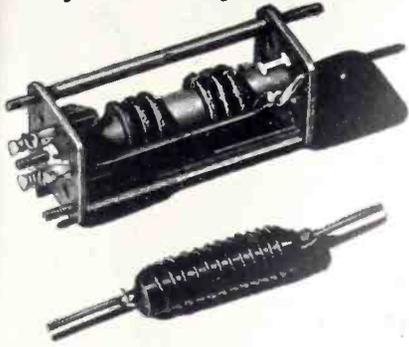
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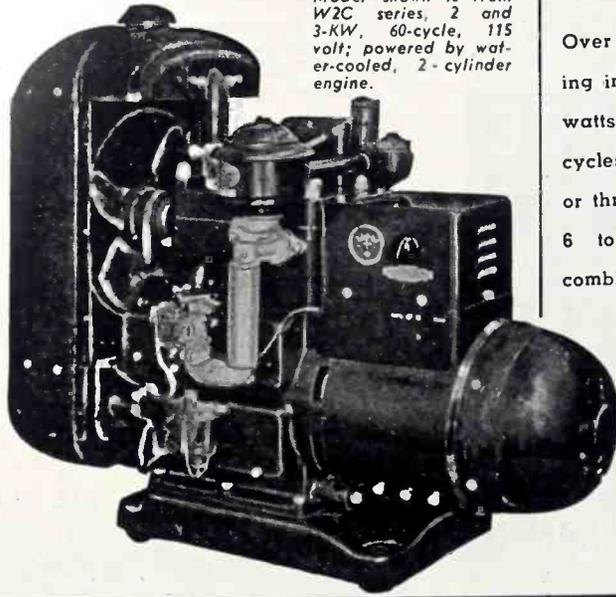
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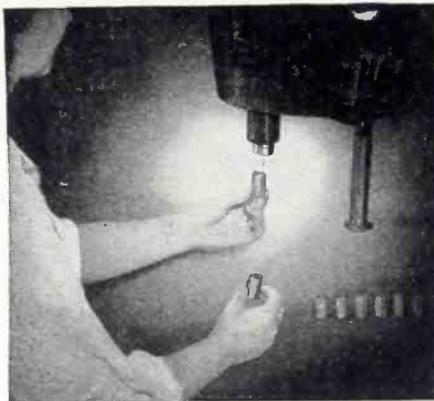


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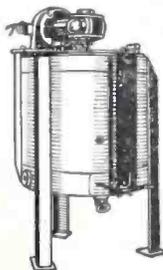
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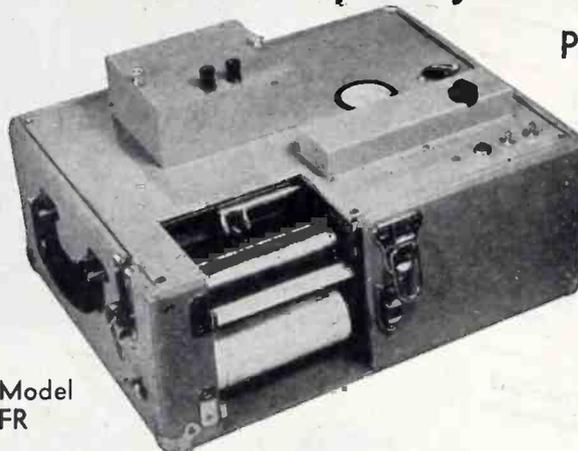
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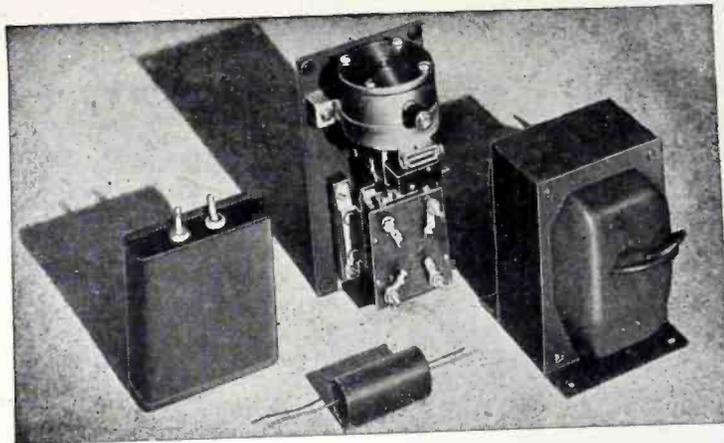
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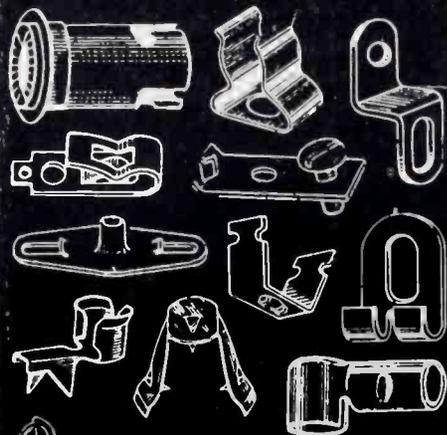
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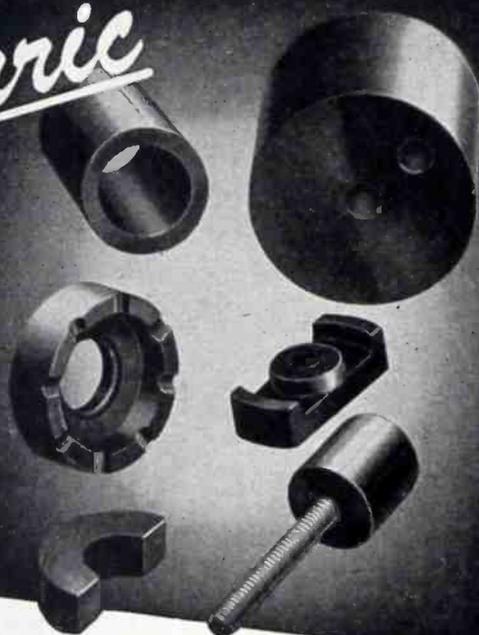
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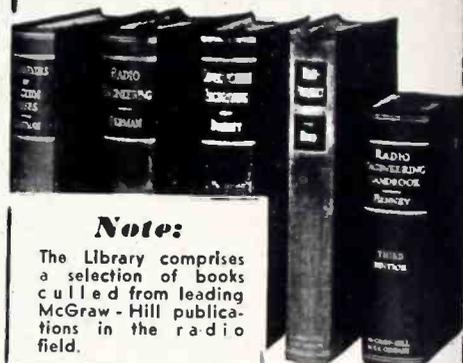
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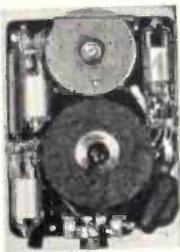
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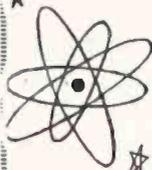
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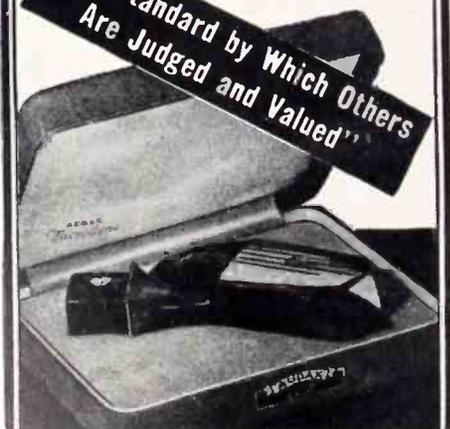
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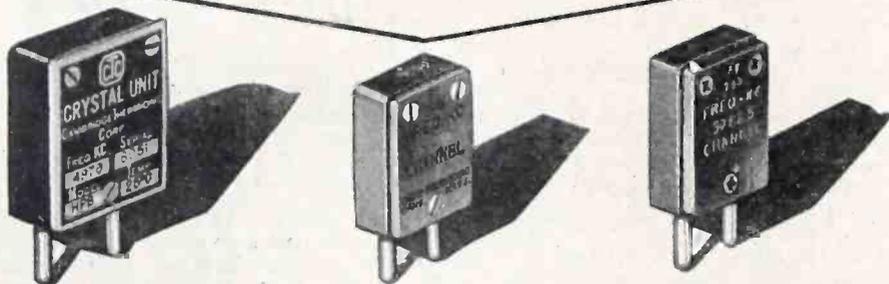
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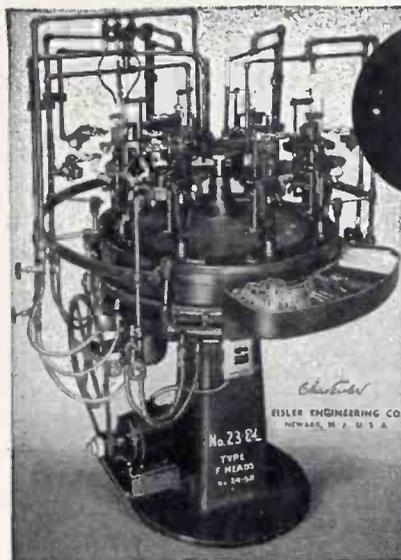
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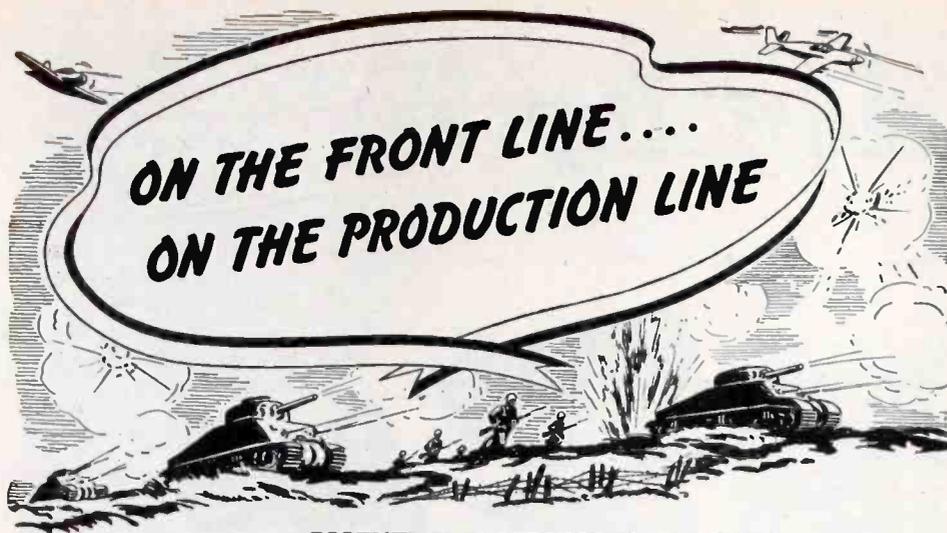
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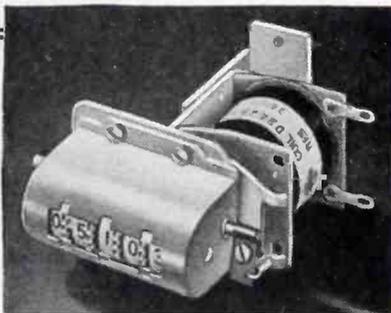
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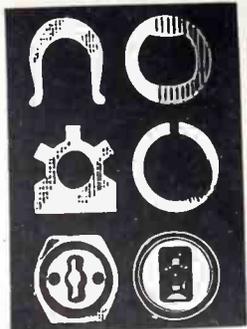
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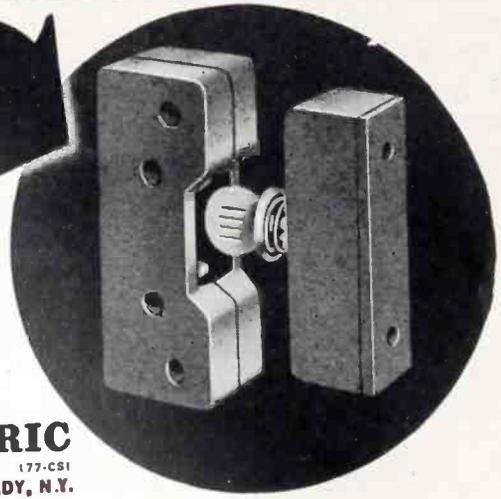


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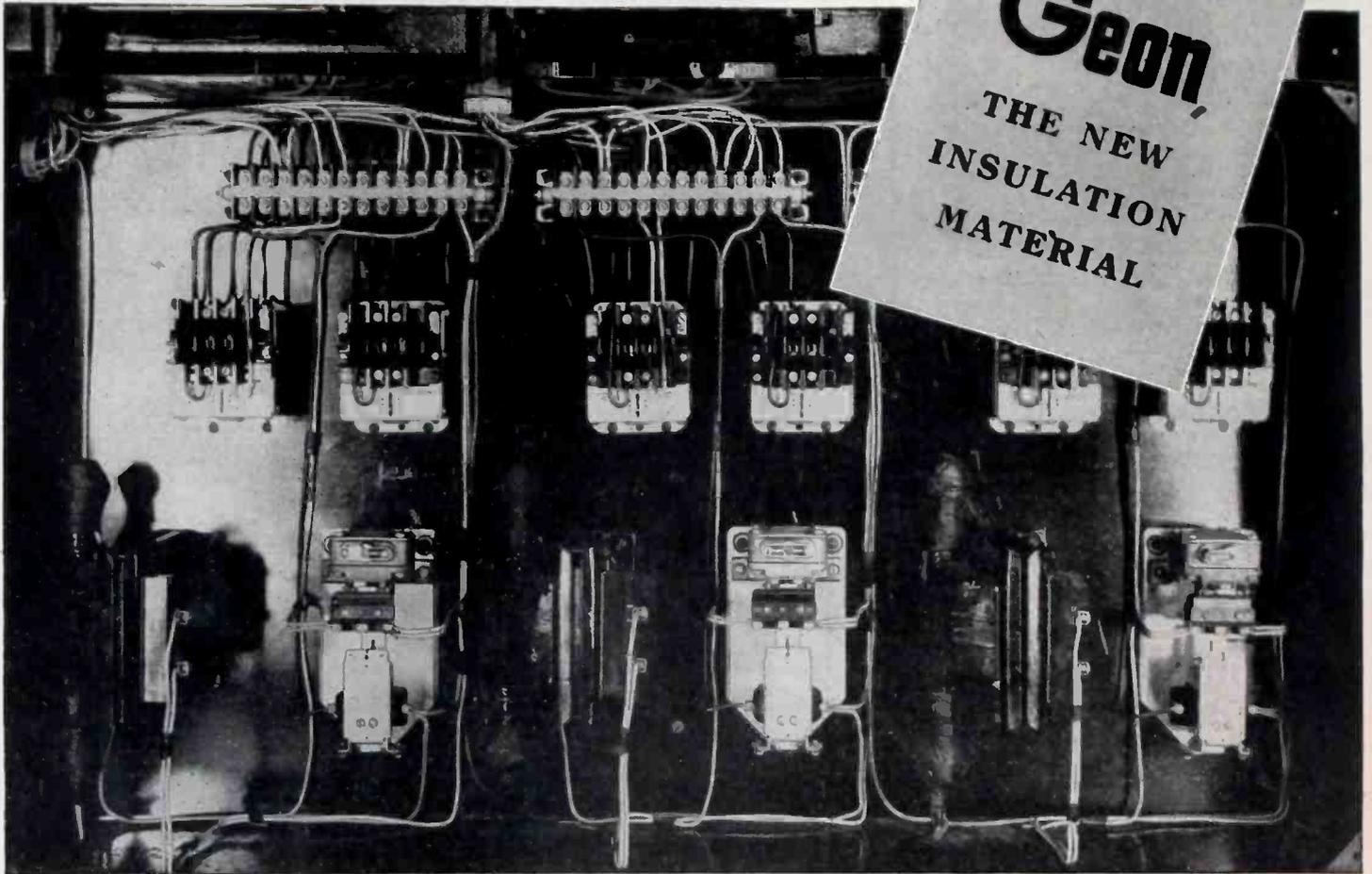
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